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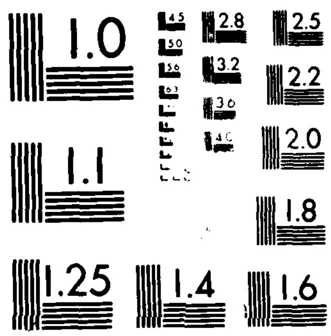

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TECHNICAL REPORT

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SPIN FREQUENCY DETECTION IN THE SPECTRAL DOMAIN

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March 1986

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This research involves the development, implementation and optimization of algorithms for tracking the spectral spin frequency representations of a revolving cylindrical target having four protruding scatterers. The investigation is limited to coherent phase and amplitude data that are constant to within a few millimeters per second with respect to the base of the cylinder, spin frequencies between five and fifteen Hz, and an absolute spin frequency rate of change less than 1.25 Hz per second. The research was conducted such that the algorithms and procedures that were developed could be performed by analysts who are relatively unskilled in this analysis. The heuristic methodology utilized in this effort is one wherein a working model of the expert analyst's problem-solving approach is obtained by observing him perform the manual procedure, generating the associated protocols, and then programming this intelligence into the machine. The manual procedure was easy to understand and to implement in the machine.

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INTRODUCTION

This research involves the development, implementation and optimization of algorithms for tracking the spectral spin frequency representations of a revolving cylindrical target having four protruding scatterers. The investigation is limited to coherent phase and amplitude data that are constant to within a few millimeters per second with respect to the base of the cylinder, spin frequencies between five and fifteen Hertz (Hz), and an absolute spin frequency rate of change less than 1.25 Hz per second. The research was conducted such that the algorithms and procedures that were developed could be performed by analysts who are relatively unskilled in this analysis. The heuristic methodology utilized in this effort is one wherein a working model of the expert analyst's problem-solving approach is obtained by observing him perform the manual procedure, generating the associated protocols, and then programming this intelligence into the machine. The manual procedure was easy to understand and to implement in the machine.

THEORY

In the coherent doppler processing of radar data from targets with multiple scattering centers, a frequently used method for information display is the doppler history plot. In this plot, the doppler content of the signal, i.e., the velocities of the various scattering centers relative to the radar are displayed as a function of time. The plot is generated by moving a window of predetermined size through the amplitude and phase data, at an appropriate lag, and mapping the contents of each window into the spectral domain. Next the spectra are sequentially plotted, equispaced, one behind the other, using hidden line plotting techniques. Figure 1 shows an example of a typical doppler history plot.[1]

In this plot, each peak's location in the frequency spectrum is directly proportional to the average relative velocity of the scattering center it represents. A peak in the positive portion of the spectrum represents a scattering center moving towards the radar, while a peak in the negative portion represents a scattering center moving away from the radar. Radial velocities corresponding to the spectral frequencies are shown in meters per second in the bottom scale. The relationship between radial velocity and doppler frequency is directly proportional to the wavelength of the radar, as seen in Equation 1.

$$\dot{R} = \lambda/2f_d \qquad (1)$$

where $\dot{R}$ = radial velocity (m/sec)

λ = radar wavelength (m)

f_d = doppler frequency

If a scattering center has an associated velocity too large to be represented on one side of a spectrum a velocity ambiguity occurs and the peak

representation appears wrapped around to the other side of the spectrum. This particular effect is classically known as "aliasing," and occurs when the Nyquist criterion is not met, i.e., when the sampling rate is less than twice the highest frequency component present in the data.

The first two steps in the investigation involve associating the velocity information in the doppler history plot with the spin frequencies of the subject target, and then determining the variation of doppler processing which best displays the spin frequency content for subsequent tracking. The first step is achieved by examining the scattering center orientation of the target, with respect to the radar line of sight. The second step requires examination of long-term Fourier transforms, those encompassing several cycles of spin, which bring up the FM sidebands of the spin modulation.[2]

Examination of target scattering center orientation began with the analysis of Figure 2.

As shown, the four scattering centers that produce spin frequency effects in the doppler history plot are symmetrically located with respect to the axis of the cylinder. Dominance of the spectral spin information is due to the relatively long distance they extend out from the cylinder, as opposed to any other scatterers which may exist near the surface. Since this distance and the carrier frequency are constant, the spin doppler excursion is determined by the target aspect angle, Ω. As shown in Figure 3, Ω, which varies between 0 and 90 degrees, is defined to be the angle between the radar line of sight and the spin axis of the target. The mathematical relationship for the excursion of spin doppler is expressed in Equation 2.

$$\Delta f = 4\Pi f_s \frac{df_c}{c} \sin \Omega \qquad (2)$$

where

Δ_f = excursion of spin doppler

f_s = spin frequency

d = distance from spin axis to scatterers

f_c = carrier frequency

c = speed of light

Ω = angle between radar line of sight and spin axis

Equation 2 shows that spin doppler varies sinusoidally from 0 when $\Omega = 0°$, i.e., the radar line of sight is aligned with the axis of the target, to a maximum when $\Omega = 90°$, i.e., the radar line of sight is perpendicular to the axis

of the target. Alternately, this information can be expressed in terms of the modulation index, β, as shown in Equation 3.

$$\beta = \frac{\Delta_f}{f_s} = 4\pi d\frac{f_c}{c} \sin \Omega \qquad (3)$$

The modulation index also increases as Ω tends toward 90°, thus placing more of the power into the FM sidebands of the spin information. However, due to the four-fold symmetry of the scatterers, only multiples of four times the spin frequency appear in the sidebands, as opposing doppler returns from the symmetric scatterers usually cause cancellation of all intermediate returns.

The next step in the research involved examination of long-term Fourier transforms, those encompassing several cycles of spin, in order to develop a reasonable display of the sidebands present. This effort began by considering the situation depicted in Figure 4a. Here, a single scattering center is shown spinning about its tip, with the radar line of sight in the plan of rotation, i.e., Ω = 90°.

Next, Figure 4b was developed, depicting representative spectral information that would be received by the radar in this case. The left-hand side of Figure 4b shows a doppler history plot encompassing two cycles of this target's spin, where a very narrow transform window would need to have been used for near instantaneous frequency representation. The right-hand side of Figure 4b shows the corresponding single spectrum contents of windows, which contain a negative half cycle, a full cycle, and a positive half cycle of spin, from top to bottom, respectively. This figure indicates that only a transform window, encompassing at least a full cycle of spin, can contain all the FM sidebands of spin modulation.

As a proof of this indication, doppler histories were generated from typical amplitude and phase data from the subject target for Fourier transform windows encompassing 1/5, 2/5, 4/5, 8/5, 16/5, and 32/5 cycles of spin. These doppler histories are displayed in Figures 5 through 10, respectively. Inspection of these doppler histories gave evidence of the spin sideband tendency to settle into a single spectrum as the transform window approaches a full cycle of spin. Further, as the transform window expands to encompass several cycles of spin, fewer sidebands are lost due to temporary destructive interference; and their representations sharpen, due to the increased number of points in the window. This effect allows for more precise manual frequency determination.

Two other points are worthy of note in Figures 5 through 10. First, the total normalized power in each of the spectra is equal, as was the case in Figure 4b between the 1/2 cycle and full cycle spectral displays. Therefore, increasing the length of the Fourier transform window has no effect on the total normalized power in each spectrum, but rather on how the power is distributed, i.e., according to the spectral content. Second, the lag used in moving the transform window through the data was equal to the length of the transform window. This implies uncorrelated spectra, i.e., no common time domain data is used in the production of previous or successive spectra. Figure 11 is

equivalent to Figure 10, except that each adjacent pair of spectra is correlated. Using a lag of 1/2 the size of the transform window, each spectrum is computed with 1/2 of the time domain data used to compute each of its adjacent neighbors. Correlated spectra is frequently produced in doppler history displays to achieve the effect of smearing the spectral peaks as a function of time, thus leaving traces of scattering center velocities which are more pleasing to the human eye.

For the subject target, the number of points in each transform window was chosen to be 256, so as to encompass at least four cycles of spin and to give reasonably sharp spin traces. Production of noncorrelated spectra, i.e., lag equal to 256, was chosen for subsequent tracking, as the human eye was not intended to be part of the automated process; and also in that this reduces the computational workload. It was noted that reduction of a given lag, by a factor of two, doubles the number of spectra that must be produced and subsequently handled. A lag greater than the transform window would further reduce the computational workload; but this was determined unfeasible, as information would be lost in the doppler display.

As noted in the introduction, the phase and amplitude data that are used are constant to within a few millimeters per second, or normalized with respect to the base of the cylindrical target. Unfortunately, the relatively large amplitude of the base return frequently causes spin returns not to be seen in the normalized doppler history display. Therefore, for the spin doppler history displays presented in this paper, the base return has been filtered out of each spectrum after normalization, in order to bring up the sidebands of the spin modulation.[3]

TRACKING PROBLEMS AND THE MANUAL TRACKING PROCEDURE

This research has identified four classes of problems in the doppler history data which have, to date, inhibited the development of an automated process for tracking spin frequencies. These problems, which may occur in any combination, are:

- Noise, used here in a general context to describe both random noise and undesired clutter returns.
- Periodic fading or cancellation of spin frequency returns.
- Wraparound or aliasing of the higher spin frequency multiples.
- Crossover of nonwrapped and wrapped spin returns.

For testing of automated spin line tracking algorithms to be developed, three sets of data were selected which exhibit various combinations and intensities of all four classes of problems. Data Set 1, shown in Figure 12, exhibits

fading and spin multiple crossover in a severe noise environment. Noise, as illustrated in this figure, may appear at any frequency, singularly or in clusters, and with amplitudes often larger than those of the spin returns. Data Set 2, shown in Figure 13, illustrates an example of severe fading and cancellation of spin frequency returns while in a relatively low noise environment. Such fading is due to variation in radar orientation (target's aspect angle) and destructive interference from other returns. Data Set 3, shown in Figure 14, exhibits very prominent higher spin multiples, which alias and make distinction difficult at points where they cross over lower spin multiples. Another problem is an occasional strong 60 Hertz line caused by interference; however it was considered too rare to be included as another main class problem.

The first step in the development of an automated spin frequency tracker was to observe a skilled analyst while performing such a data reduction. The following steps describe the procedure obtained from these observations.

1. A doppler history plot is generated with the following characteristics:

a. A transform window, large enough to produce reasonably sharp spin traces.

b. A lag, half the size of the transform window, to produce smearing of the spectral peaks.

c. High pass filtering, to remove the relatively large base representation.

2. Next, traces of spin frequency multiples in the doppler history plot are identified and marked. These multiples are denoted as mf_S where f_S is the spin frequency and, $m = \pm 4, \pm 8, \pm 12, \ldots$ Here again, it is noted that, generally, only multiples of $4f_S$ are present.

3. On a spectrum-by-spectrum basis, the largest mf_S, which can be identified and is not aliased, is then selected for tracking. The spin history is then calculated by measuring the zero doppler offset of these multiples, dividing by the corresponding multiple, and recording the results as a function of time.

In identifying the spin frequency traces, the analyst utilized the apriori knowledge that the actual spin frequency will be between 5 and 15 Hz, with rare exception. Using this information the analyst identifies the $4f_S$ multiple as the lowest spin frequency trace in the interval 20 Hz to 60 Hz. The $-4f_S$ multiple is identified in a similar manner. Higher multiples are subsequently identified by searching in the area of the appropriate doppler offset for that multiple. For example, if the $4f_S$ trace was located at approximately 20 Hz, the $8f_S$ multiple would be searched for around 40 Hz, the $12f_S$ multiple at around 60 Hz, and so forth. Since the error in frequency measurement for identifiable multiples is approximately equal, selection of the highest multiple minimizes error in the calculated spin frequency as the measurement is divided by that multiple. Aliased multiples are not considered, due to their

generally lower relative amplitude, and due to the additional constant that must be included in the calculations. When fading occurs, the next lower, identifiable multiple is selected for tracking. When higher multiples alias and crossover traces currently being tracked, the analyst has the advantage of following the general trend of the trace under track and, thus, usually avoids confusion between spin representations. In cases where no spin multiples are identifiable due to noise and/or fading the analyst usually interpolates these areas with the values of previously and successively tracked spin frequencies. Noting that such measurements and calculations are very labor intensive on a spectrum-by-spectrum basis for long periods of track, the analyst will frequently make measurements only on every third or fifth spectrum and interpolate the others as long as the data are relatively clean and this can be done without loss of continuity or track. Obviously this is not always the case due to the tracking problems that are involved. Figure 15 illustrates the manual analysis where only three spin frequencies have been calculated.

INITIAL TRACKING PROCEDURES

As an adjunct to observing the skilled analyst perform the manual tracking process, work on a similar problem by graduate students at the Cognitive System Laboratory, University of California at Los Angeles (UCLA) was also reviewed. In this work spin doppler returns from a similar target were simulated in order to develop like tracking algorithms. These algorithms were developed on the basis of two fundamental assumptions.

First, a given candidate spin representation in a particular positive half spectrum should have a like representation in the negative half spectrum. Second, an algorithm should be able to locate, in previous and successive spectra, similar candidate returns which follow a particular spin frequency trend. Therefore positive frequency trends should be correlatable with their counter representations in the respective negative half spectrum. This process started with a Monte Carlo type simulation, where positive and negative spin frequency representations were generated and then combined, constructively and destructively, with randomly generated noise, and used as the basis to compute the doppler power spectra. Next, the tracking algorithms would, for each spectrum, select symmetrically located peaks as candidate spin frequency returns. Previous and successive spectra would then be examined, to determine if the candidate returns fit within candidate spin frequency trends. Those candidate returns which did not fit would then be eliminated. Finally, the chosen spin frequency trends would be selected, using the apriori knowledge that they should be multiples of four times the fundamental spin frequency and should last, for the most part, for the duration of the data, i.e., short spurious trends would be eliminated. The spin frequency as a function of time would then be calculated from these trends.

This process proved difficult to implement on available computational hardware, slow in terms of total execution time, and usually failed to obtain the correct spin frequencies when applied to real data. Processing equipment used for the implementation was a Digital Equipment Corporation PDP-11/55 with floating point hardware, 256 kilobytes of memory, a 176 megabyte storage disk, 128 kilobytes

of fast access disk emulator storage, an array processor which had not been implemented in software, 7 and 9 track magnetic tape capabilities, and a graphics terminal with hard copy. The first problem in the hardware implementation of the process was the limited memory available for the doppler history data which the algorithms operated upon. Since the fast access disk emulator storage was too limited to contain all of the data, it was necessary to store it on the substantially slower disk, and frequently swap small portions of it in and out of main memory as the processing algorithms required them. This continuous swapping, in addition to the time required for processing of the algorithms and the time needed to conformally map the data to the spectral domain, further made the entire process intollerably slow. The major drawback of the process, however, was the frequent failure to obtain the proper spin frequencies. Intensive manual analysis of the process and results showed the failures to be primarily due to the assumption that candidate spin returns will appear symmetrically about zero doppler. In the simulations conducted at UCLA, this was not a problem as the simulated doppler histories were produced noncoherently, thus insuring symmetric representations. For the real data used in this application, however, such was not the case as it is processed coherently. Attempts to modify the process and remove the symmetry requirements of candidate spin representations showed insufficient improvement in proper spin frequency identification.

While the process developed at UCLA appeared inadequate for the problem at hand, it did demonstrate that available memory and speed of conformal mapping were problems to be reckoned with. Indeed, any tracking algorithms developed would need conformally mapped data to operate on, as well as a place to store it. In order to speed up the mapping process, implementation of the array processor was investigated. The result of the effort was the development of software which performed Fast Fourier Transformations (FFT) through a series of subsequent calls to array processor subroutines. The software also used the array processor to compute the doppler power spectrum. This software is listed in Appendix A as subroutine FFT2. While benchmark speed tests of the software showed that, after initialization, the array processor performed the required function more than 25 times as fast as the main processor, there were still additional drawbacks associated with its use. The first drawback was the 16 kilobyte main memory requirement for array processor software storage. The second drawback was the fact that if the software was swapped out of main memory or windowed out of the 64 kilobyte execution window in main memory, the array processor would need to be reinitialized before its next use. This was a major problem in that initialization, along with the performance of only one FFT by the array processor, took three times as long as performance of the same operation by the main processor. In other words, the advantage of using the array processor lies only in the performance of many operations between initializations. Thus, utilization of the array processor for increased conformal mapping speed placed even greater restrictions on already inadequate executable memory. It is worthy of note that a 16 bit processor such as the PDP-11/55 has an instantaneous execution window of only 2^{16} or 65,536 bytes of main memory. Further, while memory mapping allows this segment to be split into as many as eight subelements anywhere within the 256 kilobyte total allocation at any one time, the subelements must be multiples of 4096.

This, then, defines the upper subelement, array processor memory requirement of 16 kilobytes, where a kilobyte is defined to be 2^{10} or 1024 bytes.

With even more stringent requirements placed upon available main memory, due to array processor overhead, emphasis at this stage of the research was placed upon requirements for storage of doppler history data. While review of procedures used at UCLA to obtain spin frequencies showed little promise of solving this problem, a look at the manual preanalysis normalization proved to be of great value. The process first involved precise doppler alignment, to within a few millimeters per second, of the subject target's base. Next, because of the relatively large amplitude of the base return to that of the fins, the spectra were high pass filtered, to remove base effects and bring up spin representations, for easier identification in tracking. At this point it was noted, while observing the analyst perform the manual tracking procedure, that the spin representations often had the largest amplitude. Utilizing this information, it was decided to try storing only a small number of the largest remaining returns in each spectrum as an information base of candidate spin returns. First, each spectrum was further high pass filtered, up to the minimum $\pm 4\ f_s$ requirement in this effort, i.e., $\pm 4\ f_s$ min = $\pm 4 \times 5$ Hz = ± 20 Hz. This had the effect of removing any additional undesired returns of large amplitude in this interval from consideration. Next, thirty was chosen as the number of peaks with largest amplitudes to be considered as candidate spin returns in each spectrum. Thirty was chosen simply as a worst case guess, based on observation of data at hand. However, after analysis of candidate peak selections for different sets of data, it was discovered that many candidates often described the same peak. This was primarily due to the fact that the peaks were not of infinitesimal width. Consider Figure 16, selection of candidate spin returns, which denotes (as circled) the five largest amplitudes of twenty. While these points indeed represent the largest amplitudes, in reality the dominant peaks are those indicated by vertical arrows. After only short-term manual analysis, the solution to the problem appeared obvious. The peaks represent points at which the slope changes from positive to negative with left to right taken as a positive direction. Utilizing this fact, points of positive-to-negative slope change are first selected as precandidate spin returns. In the case of Figure 16, element numbers 3. 7, 9, 11, 14 and 18 would be chosen. The largest of these would then be chosen as candidate spin returns. Again, in the case of Figure 16, this would correspond to elements 3, 7, 11, 14, and 18 for the five largest elements. Further, trials of this algorithm were then run on the data selected, with analysis of results showing that (in general) selection of only the 16 largest peaks gave rise to a sufficient candidate peak base for subsequent tracking. Storing only the amplitude and location of 16 points for each spectrum reduced storage requirements by 97 percent and allowed the utilization of only main memory, as opposed to main memory and the slow access mass storage media. The selection of 16 points per spectrum is based on the following assumptions:

- Try to keep the data base small without losing too much information on the spin frequency lines.

- Try to reduce the number of noise peaks in the data base.

After reviewing several sets of data it was found that, usually, the maximum unwrapped multiple is the $\pm 16\ f_s$; however, not every multiple shows in each spectrum. Therefore, 16 points per spectrum proved to be a reasonable tradeoff between information content and memory restrictions.

In order to further reduce the congestion of main processor memory, it was decided to make this portion of the process separate from the actual spin frequency tracking and computation. This had the advantage of removing the overhead software that would need to be stored in main memory to concatenate the two processes, and allowed for the independent creation (from raw data) of data bases to which tracking a spin frequency computation algorithms could be applied. The complete software development to perform this process is listed in Appendix A as main routine PEAKS1, with associated subroutines FFT2, PICK, SORTAG. Also included in this process is subroutine CONVER, which will be described later, at the point of its development in this research.

AUTOMATIC TRACKING ALGORITHM DEVELOPMENT

With the establishment of a satisfactory data base, the next step in the research was to develop tracking algorithms which duplicated the expert analyst's approach. The expert analyst, however, has the advantage of being able to visually locate the spin frequency traces while surveying the entire doppler history plot. Working with a considerably more limited data base, this luxury was not available. Therefore a method had to be devised which would properly provide initial frequency identification.

Initially, the first spectrum was simply searched for the return of largest amplitude and its location assigned to the $4f_s$ spin multiple. This selection was based on the assumptions that, generally, only multiples of $4f_s$ would be contained in the data base, with those in the lower portion of the spectrum containing the most power. Trial runs on real data were then made to check the frequency selections. Results showed that, except in cases of very clean data, undesired returns were often selected due to clutter and spin return fading in the spectrum. In order to compensate for the problem it was decided to make the program interactive and query the user. The selected return and its location are presented to the user, along with the query, if it corresponds to any spin multiple. If the user response is positive, then he is asked to enter the corresponding multiple. If the user response is negative, then he is asked to calculate and enter the initial frequency.

Once a method of obtaining the initial spin frequency was established, the actual tracking algorithm development began. The location in the first spectrum of the $16f_s$ multiple is computed and the location of each of the eight candidates for that spectrum is checked for a match, to within ± 2 Hz. If no match is found, the location of the $-16f_s$ multiple is checked for a match, and so on, successively utilizing the $+12f_s$, $-12f_s$, $+8f_s$, $-8f_s$, $+4f_s$, $-4f_s$ locations, until a match is found. Once a match is found, the spin frequency for that period is computed by dividing the location of the multiple by that multiple. Higher multiples that do not alias are searched first, since for a constant error in actual peak location division of a spin multiple by a higher

multiple minimizes spin frequency error. The 4 Hz window, used for the search, was chosen as the basis of careful hand analysis of doppler history data. This window generally seemed wide enough to accommodate for rate of change of spin frequency when used in conjunction with extrapolation techniques, and still minimize the presence of unwanted returns in the window. The candidate search frequency for the second window is taken to be the same as for the first, while the candidate search frequency for the third spectrum is a linear extrapolation of the frequencies found for the first and second spectra. Successive spectra use a three-point linear least squares extrapolation of frequencies found for the previous three spectra. This procedure was tested on several sets of very clean data and was shown to produce extremely good results. However, when subjected to data which contained much noise, fading, and/or aliasing of spin lines, the procedure frequently failed. More work was needed to overcome these problems.

Analyzing results after using the tracker in data that faded, showed that when unable to pick any frequencies, track was lost. To correct this problem, it was felt that more interactivity between the user and the program was needed. Therefore an algorithm which checked for the absence of candidate peaks was implemented. If no peaks are found for multiples of the calculated candidate spin frequency, the program then asked the user to enter the spin frequency for that particular spectrum. This approach solved the problem but also introduced another. When fading occurred for large periods, the user is queried much too frequently to supply the correct spin frequency. Since it is not necessary to calculate a spin frequency for every spectrum (as interpolation could be used afterward) selective processing was implemented in the algorithms. In this approach the user selects the portions of data he wants to process, leaving out those where fading is severe. This new approach also has the advantage of leaving out those portions where noise obscures the spin frequency lines. Another problem that arose when testing these algorithms occurred at the crossover point of aliased spin frequency lines. Analyzing the data it was found that, when crossing occurred, the tracker found at least two peaks in the window; and if the rate of change was small, it sometimes lost track. Since this problem does not occur often in each run, the algorithm was modified to prompt the user to select between the candidate peaks. The selection is kept as simple as possible, such that just a quick glance at the doppler plot will usually suggest to the user which is the correct peak to select. This approach also solved the problem of spurious noisy spikes in the search window by the spin frequency peaks. Finally, as a check to the spin frequencies obtained, the algorithms were further modified for selective application to the data in reverse order. Results of forward and backward processing could then be checked by the user for consistency.

Testing of the sets of data selected was performed and the results obtained agreed with the results an experienced analyst would have obtained by doing it manually. These results are shown in Appendix B.

For Data Set 1, the two problems encountered are noise and fading. Noise, being especially severe at the beginning and at the end of the run, will be avoided by skipping processing in these areas. Fading is more severe from 55 to 77 seconds; therefore this part is not processed. Once the run is completed

in the range from 10 to 55 seconds, the results shown are satisfactory and they agree with the results obtained by manual calculation of the spin frequencies.

Also in Appendix B, runs on Data Sets 2 and 3 are shown. Data Set 2 shows some fading, and Data Set 3 shows crossover of spin lines. Both runs were successful, and the results shown agree with manual calculations performed on the doppler plots.

KNOWLEDGE BASED SYSTEM DEVELOPMENT

Since the problem of noise, fading, and crossover of spin multiples often require more experienced analysis, consideration was given to making the developed software more 'user friendly' for easier application by a more novice analyst. After detailed analysis of the entire process, it was decided that implementation of a software superstructure, based on a generalized knowledge-based system (KBS), would normally produce better results.[4], [5] The process was, therefore, broken down into KBS's three primary elements:

- The interface.
- The cognitive engine.
- The knowledge base (as seen in Figure 17).

The interface, as seen in Figure 18 (which breaks down into external data, user, and expert interface), primarily functions as the user's two-way communication link to the expert knowledge modules and fact files which comprise the knowledge base. The external data interface is first used to create the fact files, where the current information to be processed is stored. The user interface then utilizes statistical and expert information, stored in the expert knowledge modules, to guide the user step by step through the process. These modules contain statistical averages from previously successful reductions, suggested defaults, and descriptions of what is happening at every stage of the reduction. Further, each user input is parsed and analyzed for content so that part or all of this information is available even though a numeric input is requested. This algorithm is listed as subroutine CONVER in Appendix A. Statistics on the current reduction are also available to the user, and are used to update the permanent statistics if tne user feels the process was successful. Finally, the expert user interface duplicates the user interface, except for the capability of altering the expert knowledge module.

The cognitive engine, as seen in Figure 19, is the active processing element containing the generator and evaluator functions, as well as the inference and reasoning algorithms that interact with the current problem state. Candidate spin returns are first generated as the largest returns in a given line, where the number generated is generally equal to the number of spin traces that do not alias. As mentioned previously, this function is based on the heuristic that most spin multiples present will probably constitute the larger returns, with most power contained in the lower, unaliased multiples. The evaluator function then works like the analyst, using a small search window to locate a spin return. The window center is first extrapolated to the expected areas of

the largest multiples, on each side of the spectrum, and then to successive lower multiples if a peak is not found. Problems of clutter, aliasing, and finding no peaks are then handled interactively through the use of the inference and reasoning algorithms. For example, if no peak (or more than one peak) is found, tracking is halted and the user is made aware of the problem and the location. The user then has the option of allowing the process to make its best guess, based on the current state of the problem, or to enter an overriding location. Statistics are also compiled on the number and nature of such interruptions, for the purpose of later advising the user in the event results are unsatisfactory. For instance, finding multiple peaks more often than not might indicate that a smaller search window would have greater success. In the event that an inexperienced analyst has exhausted the resources of the process and is still unsatisfied, presentation of results and statistics to a trained analyst can usually gain an expeditious solution.

CONCLUSION

The resulting product of this research contains many heuristic-based features, used by trained analysts in processing spin information, including forward, backward, segmented processing, and extraneous frequency rejection. It is worth noting that, collectively, it has made a significant advance in obtaining spin information for the subject target. The process successfully tracks the spin frequency through fading, clutter, and the aliasing of higher spin multiples back onto lower spin multiples with better than 90 percent reliability in routine reductions. Primarily, this was achieved by placing the techniques of the highly trained analyst into the process and at the immediate disposal of the inexperienced analyst. Routine processing of these parameters can now be performed in less than a tenth of the time previously required by a trained analyst. The analyst's capability to update the expert knowledge modules also reduces future reduction time by making inexperienced analysts even less dependent on their presence.

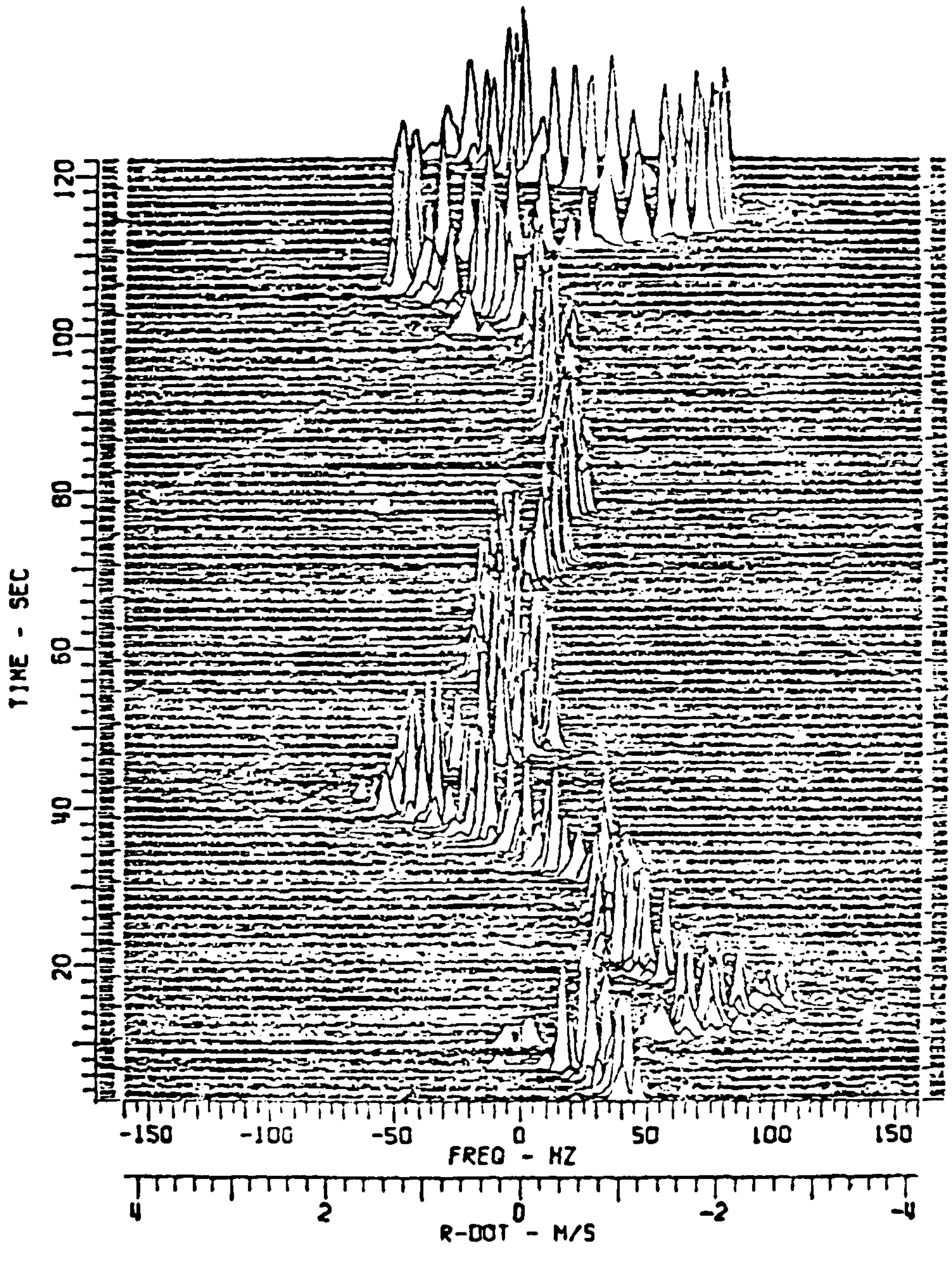

Figure 1. Typical doppler history plot.

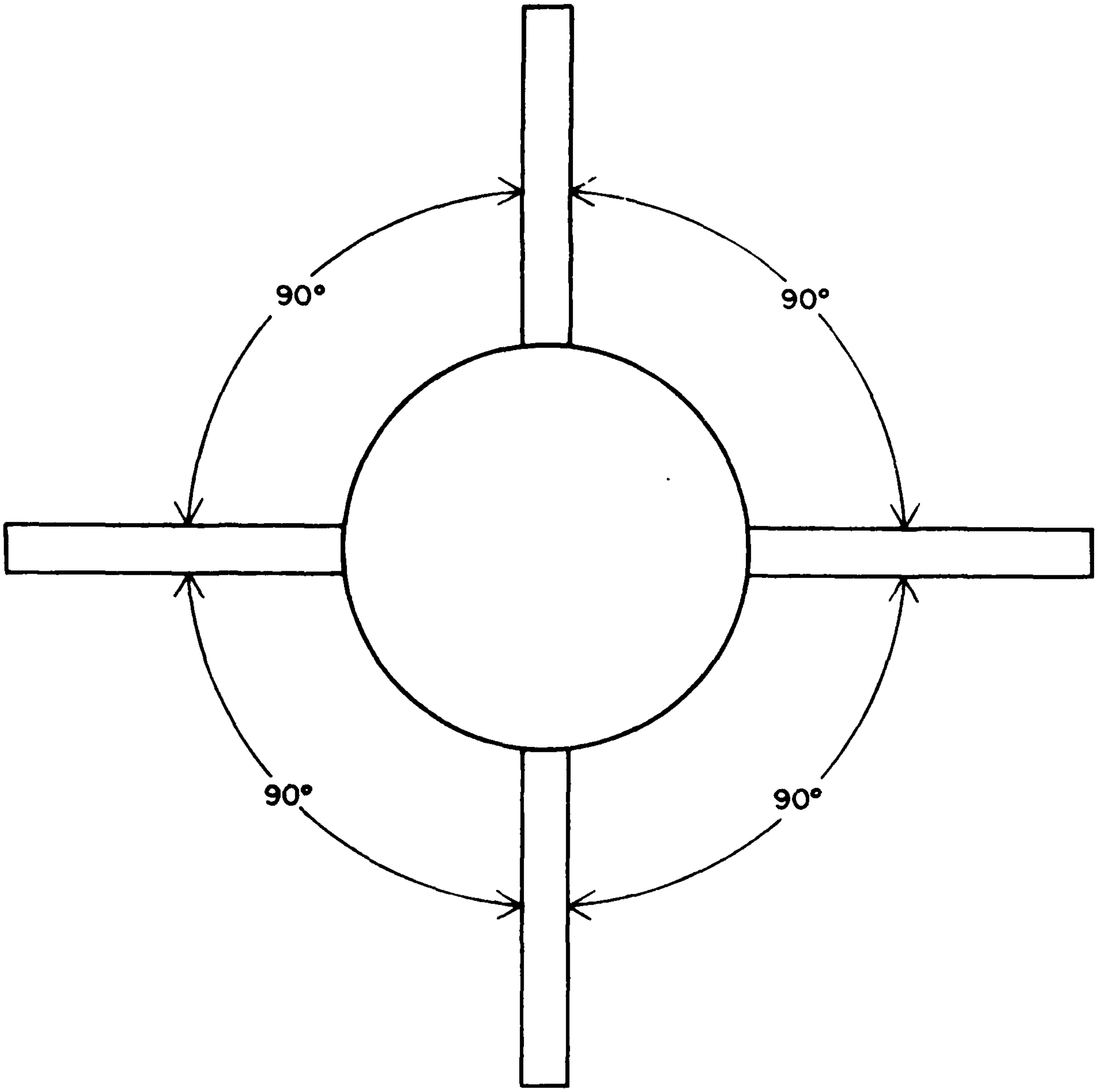

Figure 2. Target scattering center orientation.

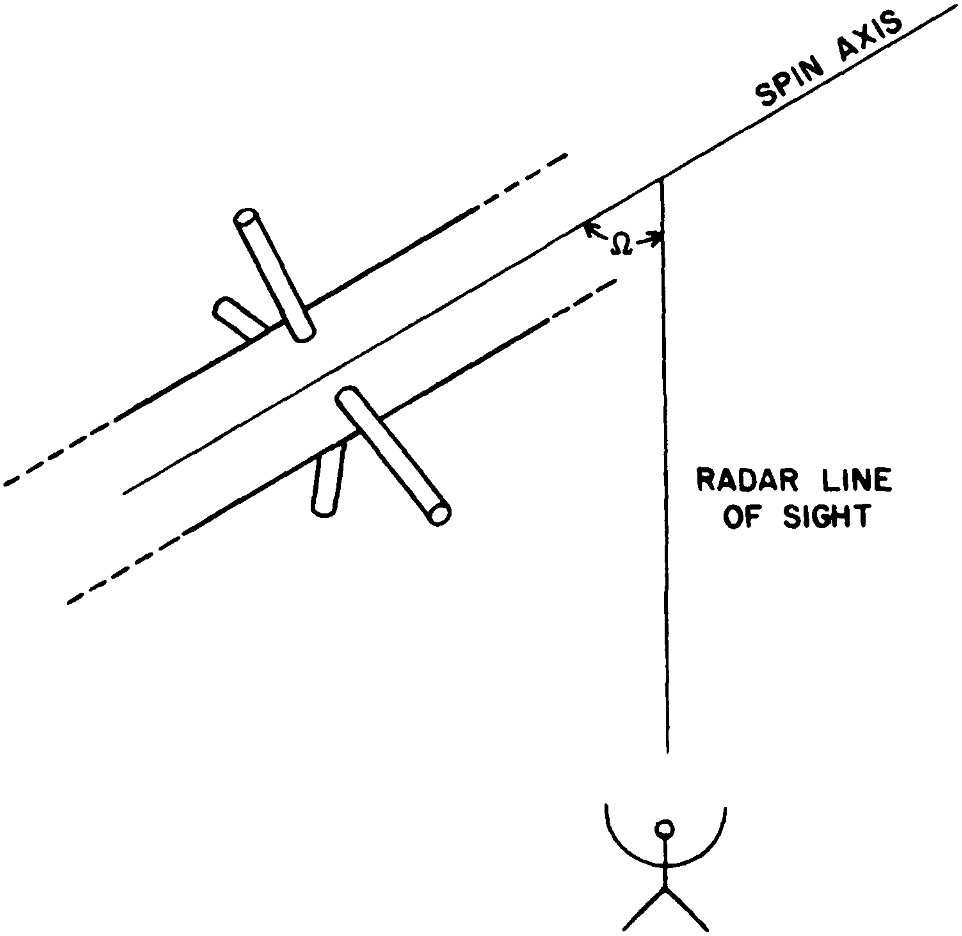

Figure 3. Target aspect angle.

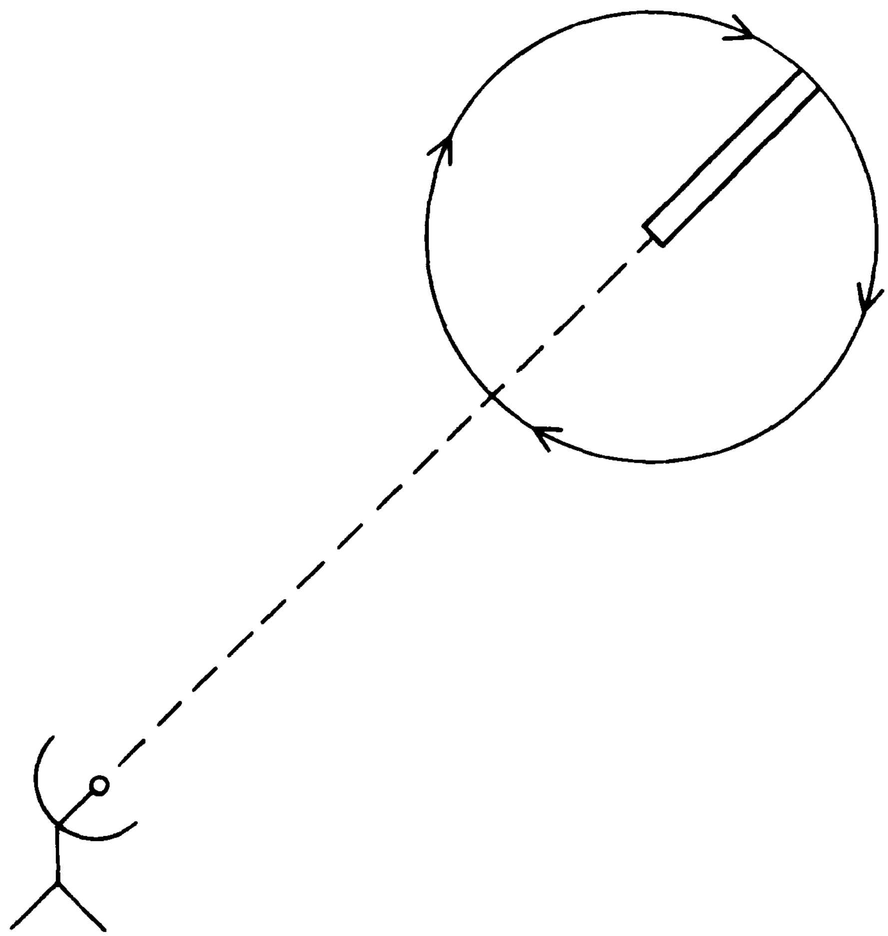

Figure 4(a). Single scattering center.

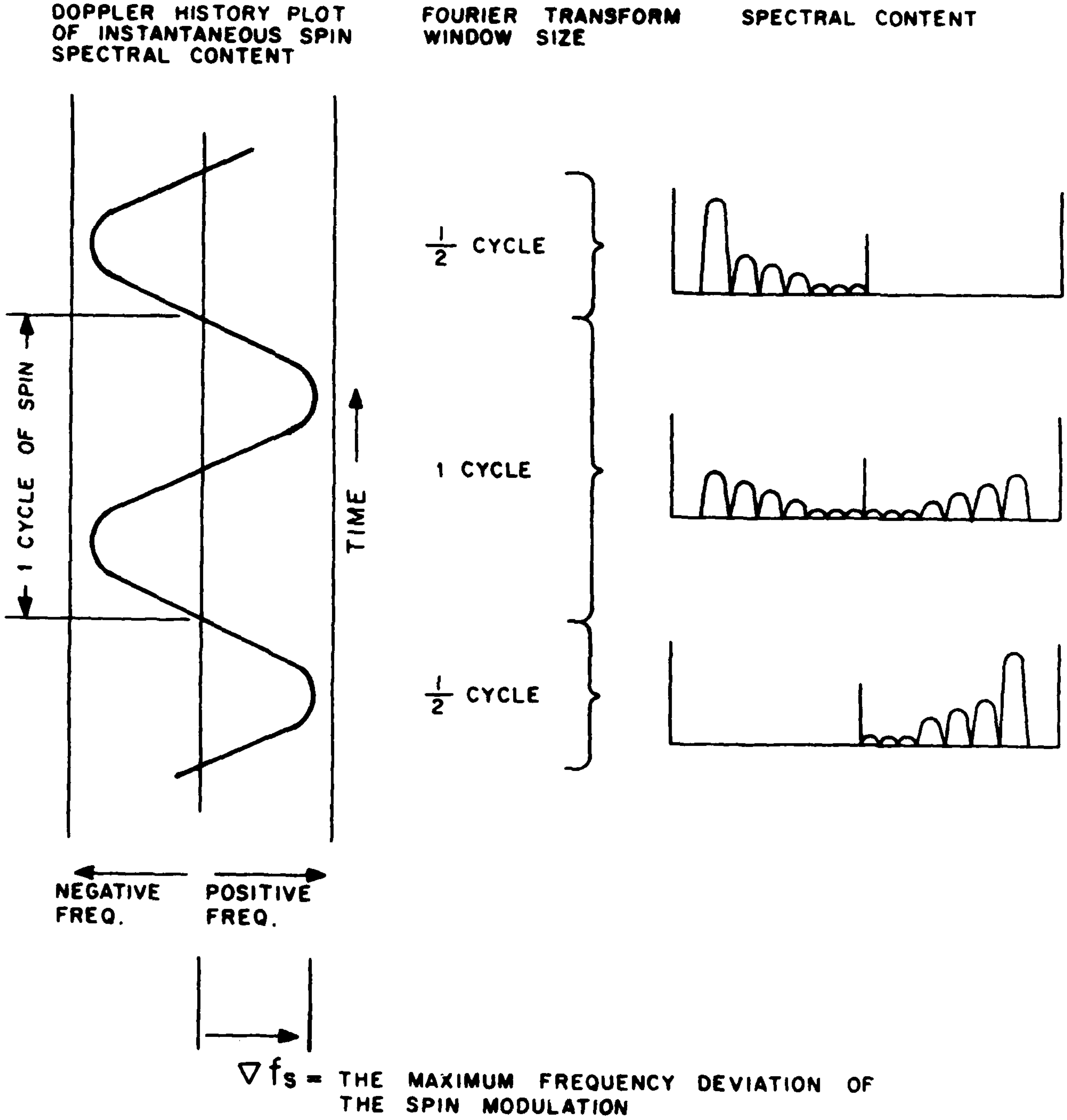

Figure 4(b). Relationship of spectral content to Fourier transform size.

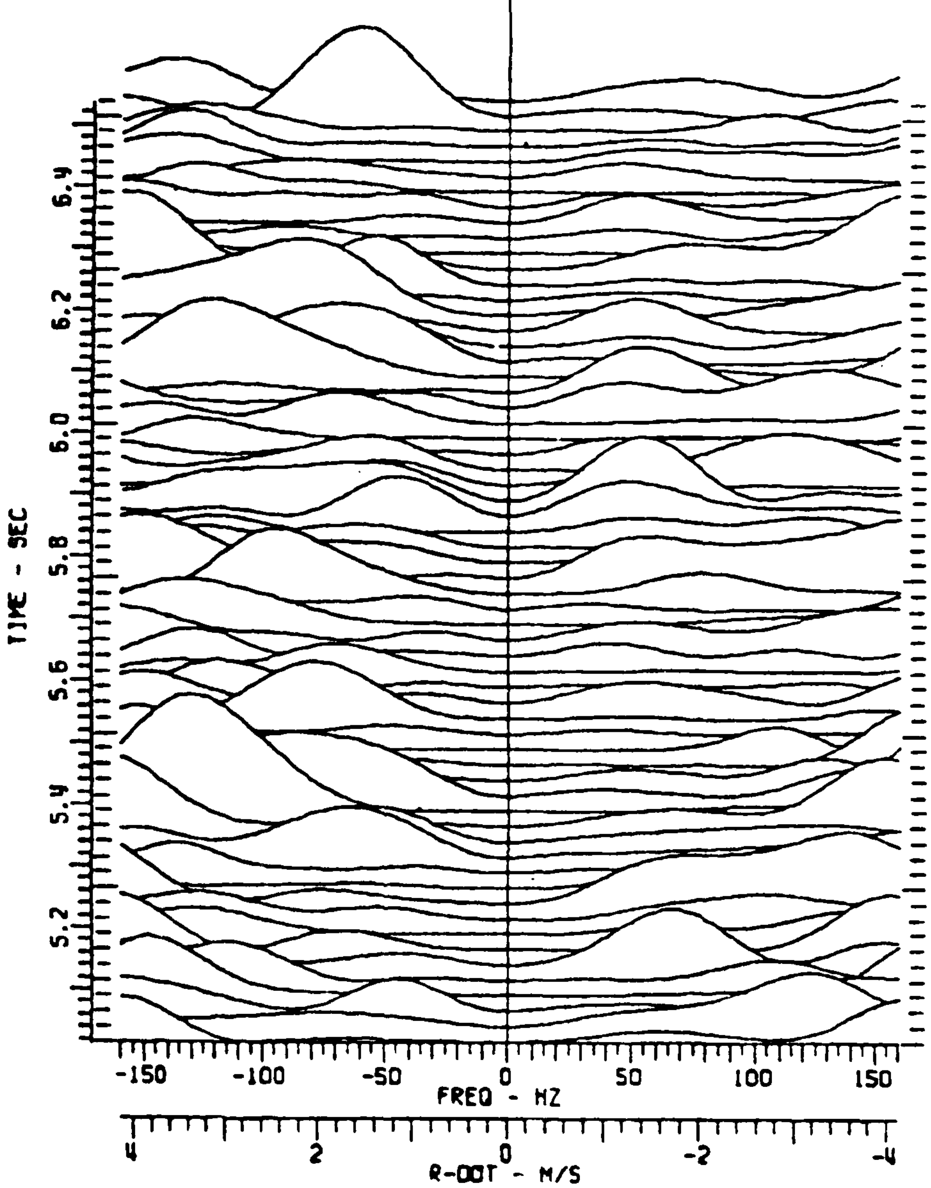

Figure 5(a). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

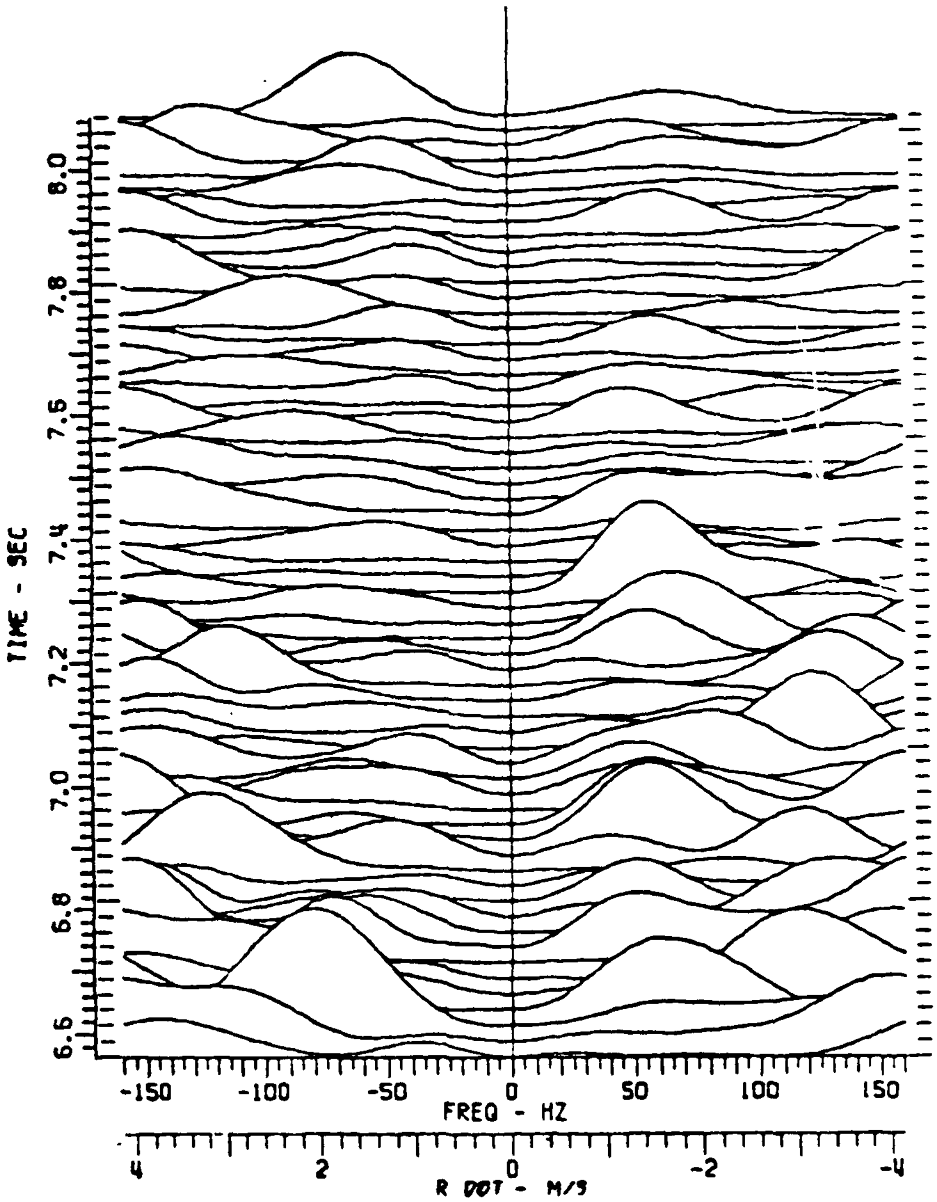

Figure 5(b). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

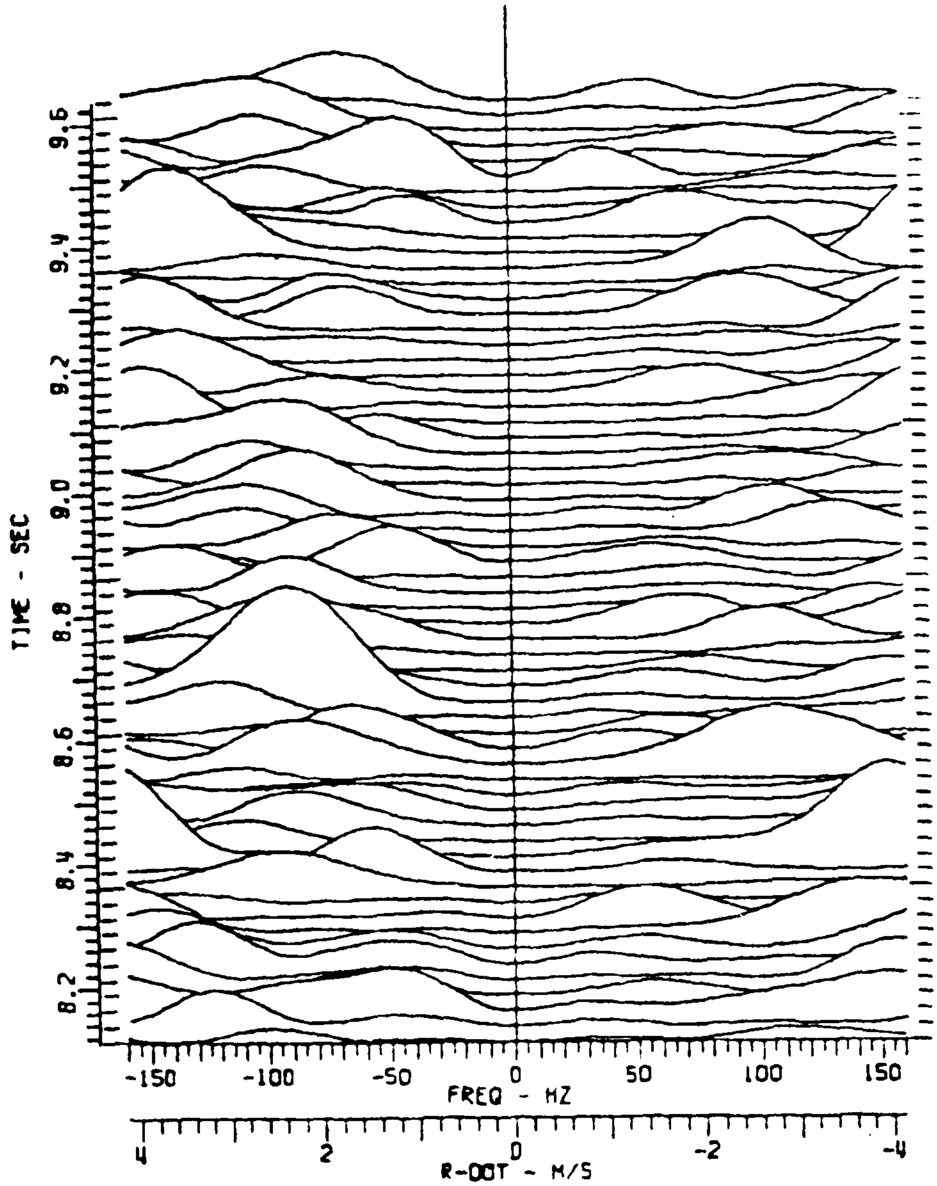

Figure 5(c). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

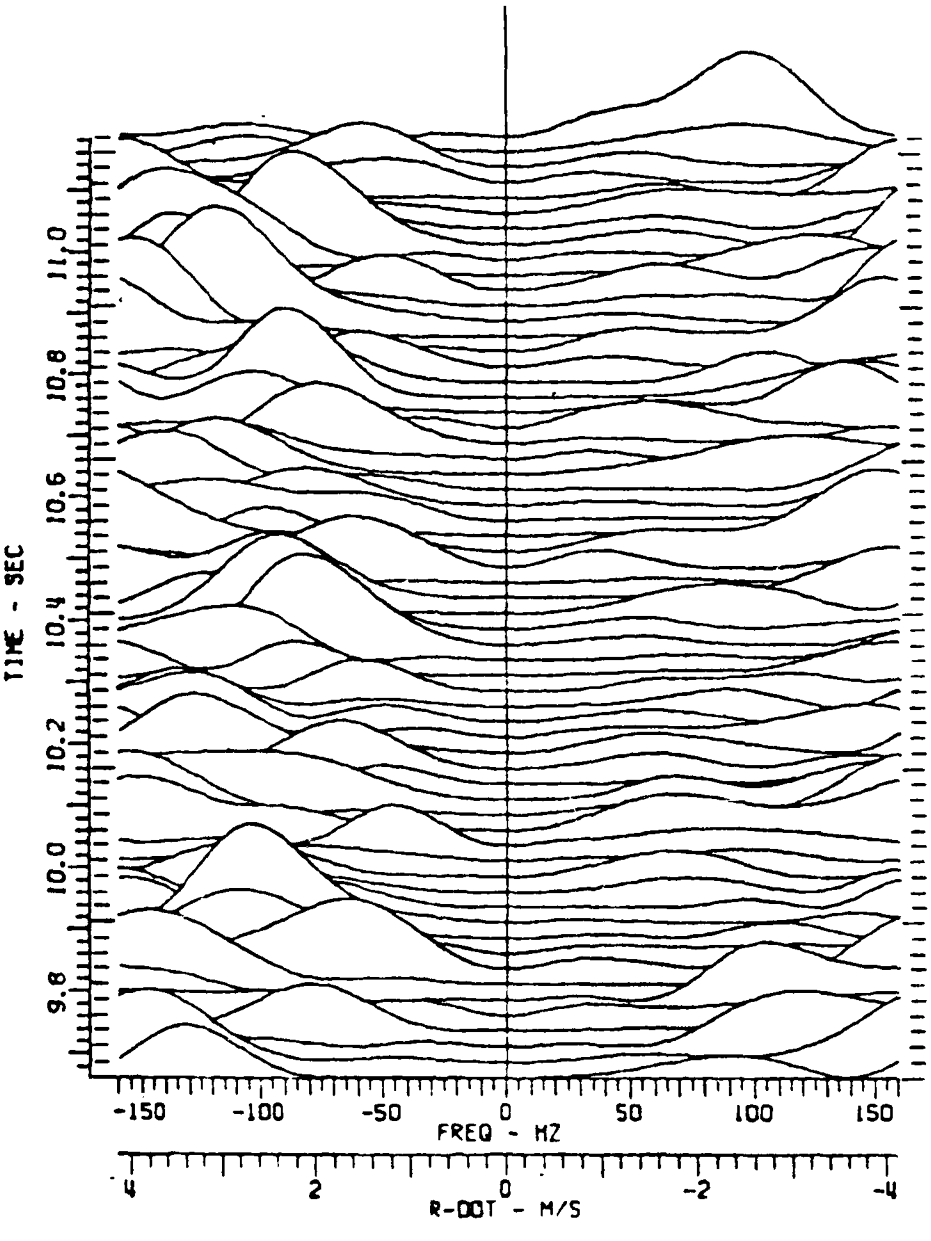

Figure 5(d). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

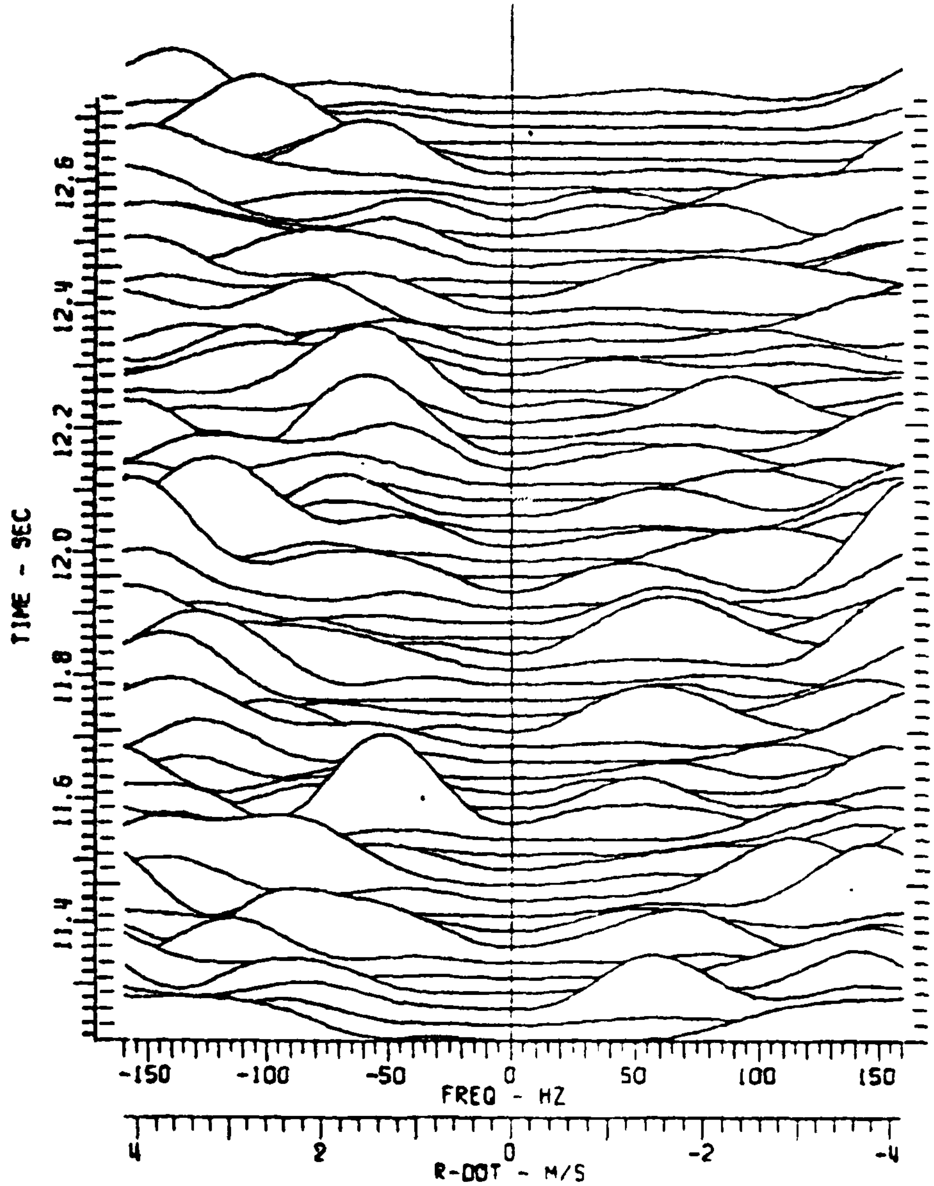

Figure 5(e). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

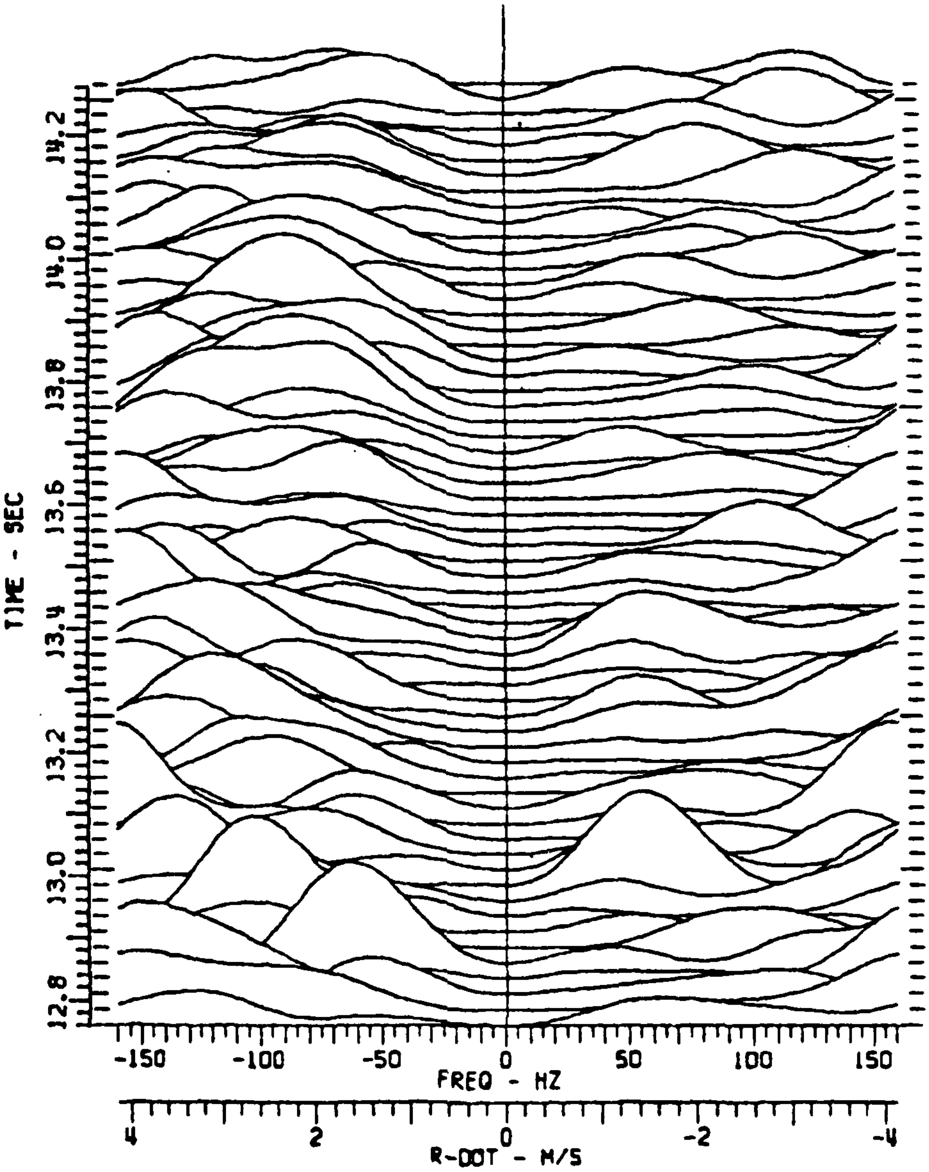

Figure 5(f). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

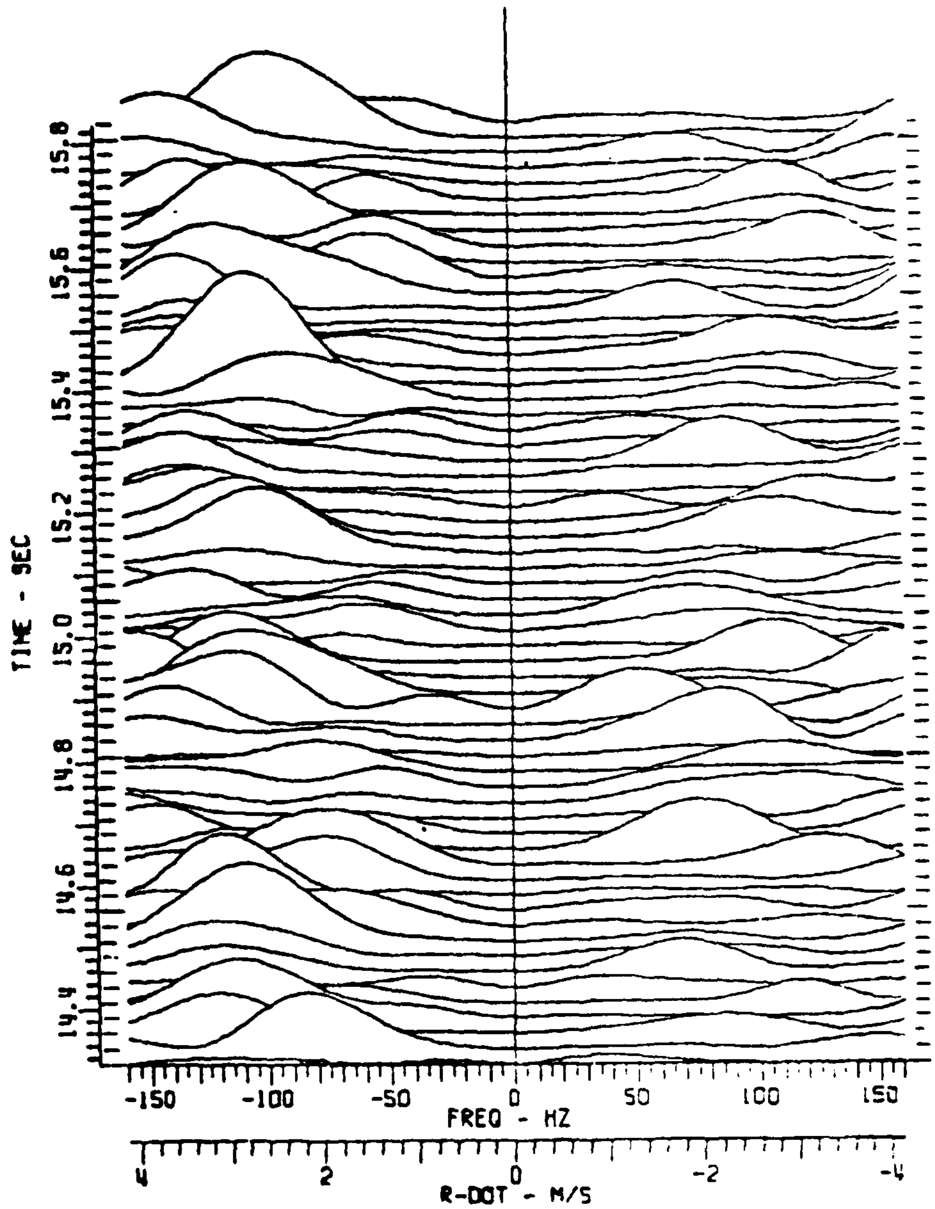

Figure 5(g). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

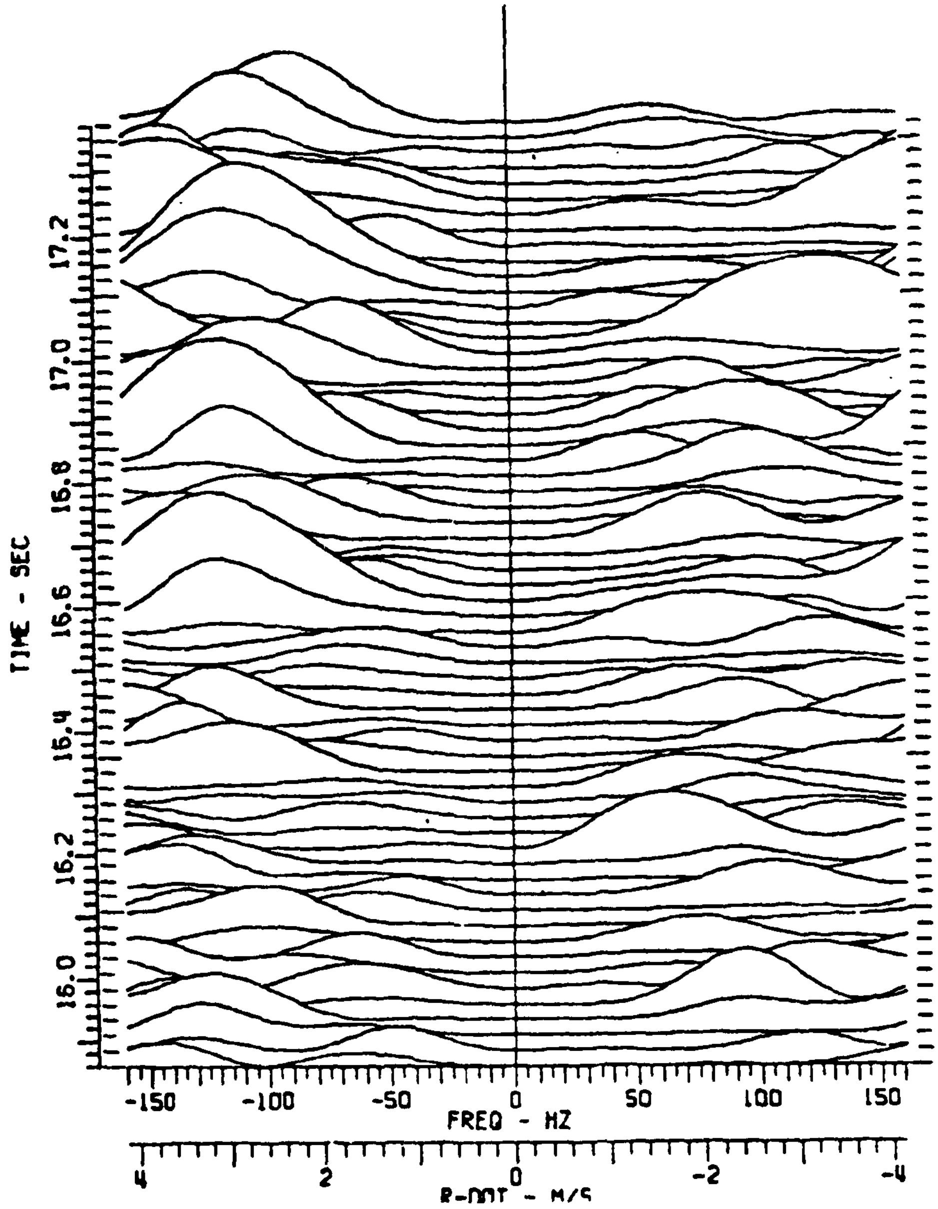

Figure 5(h). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

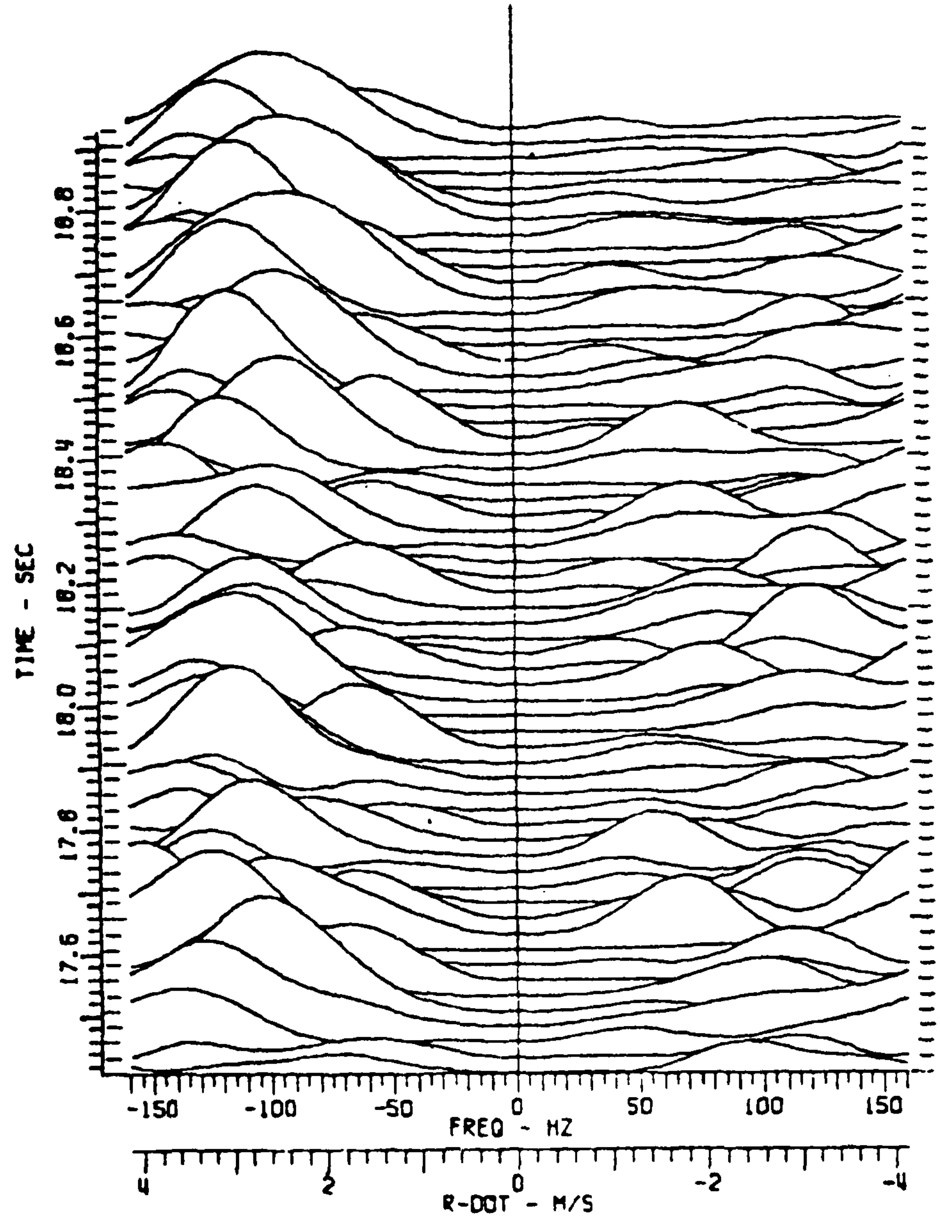

Figure 5(i). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

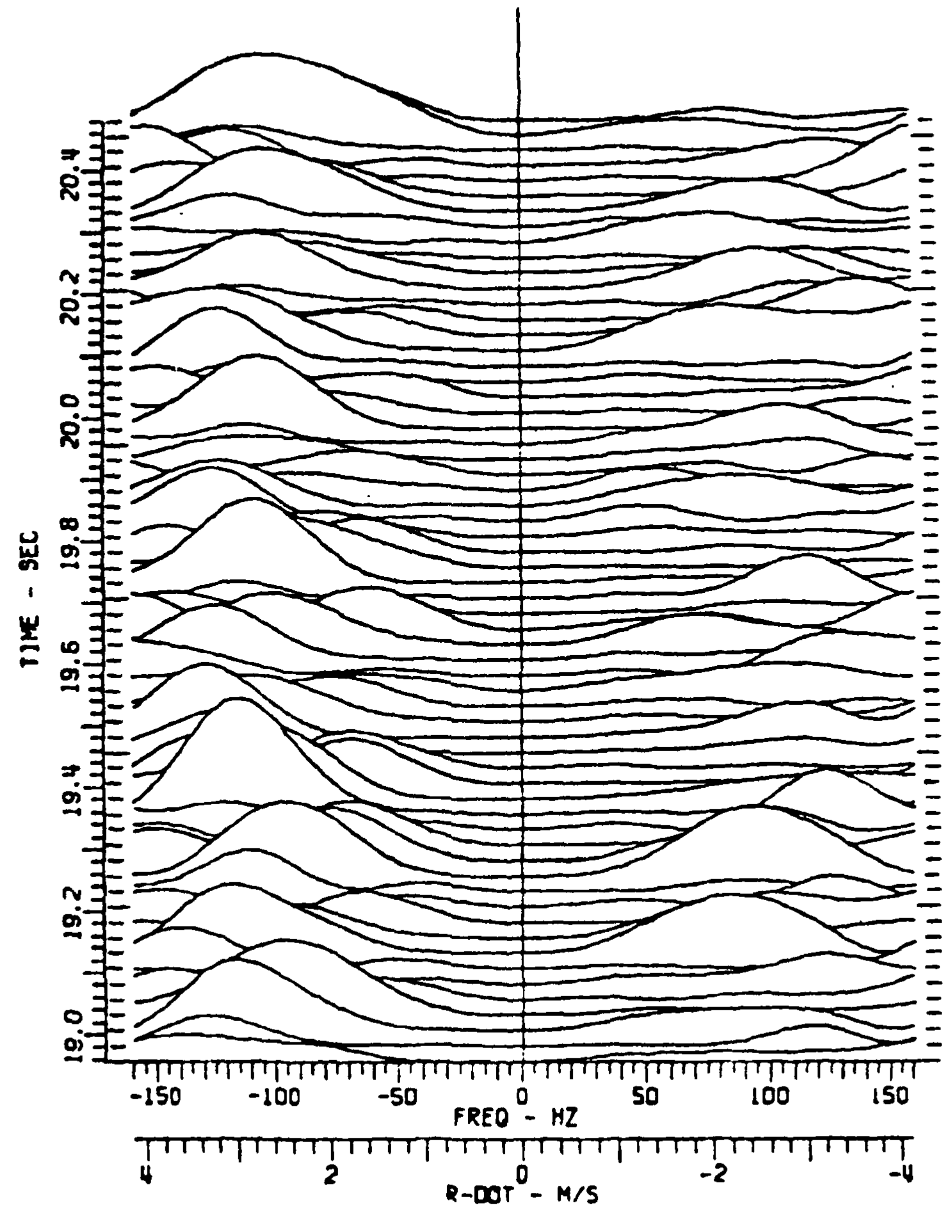

Figure 5(j). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

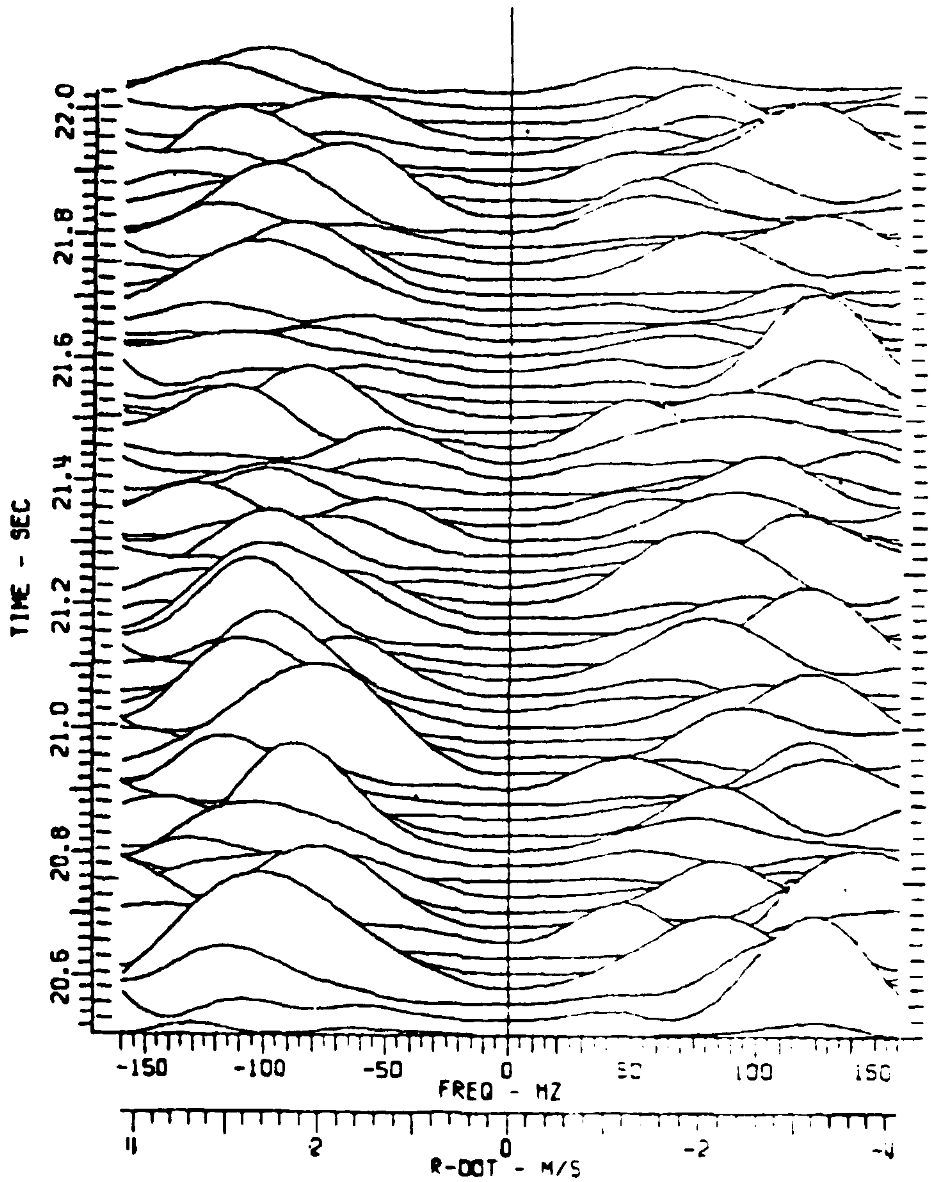

Figure 5(k). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

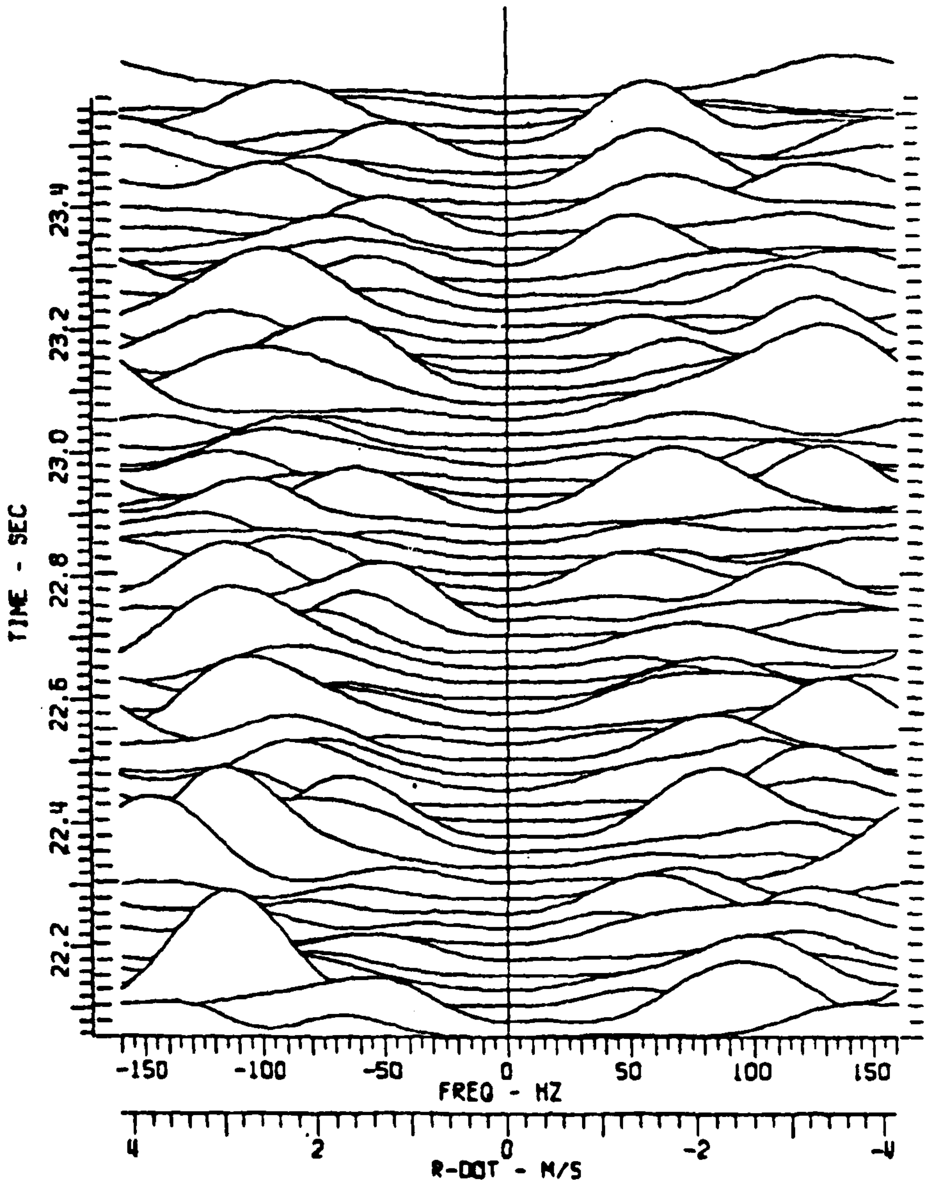

Figure 5(1). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

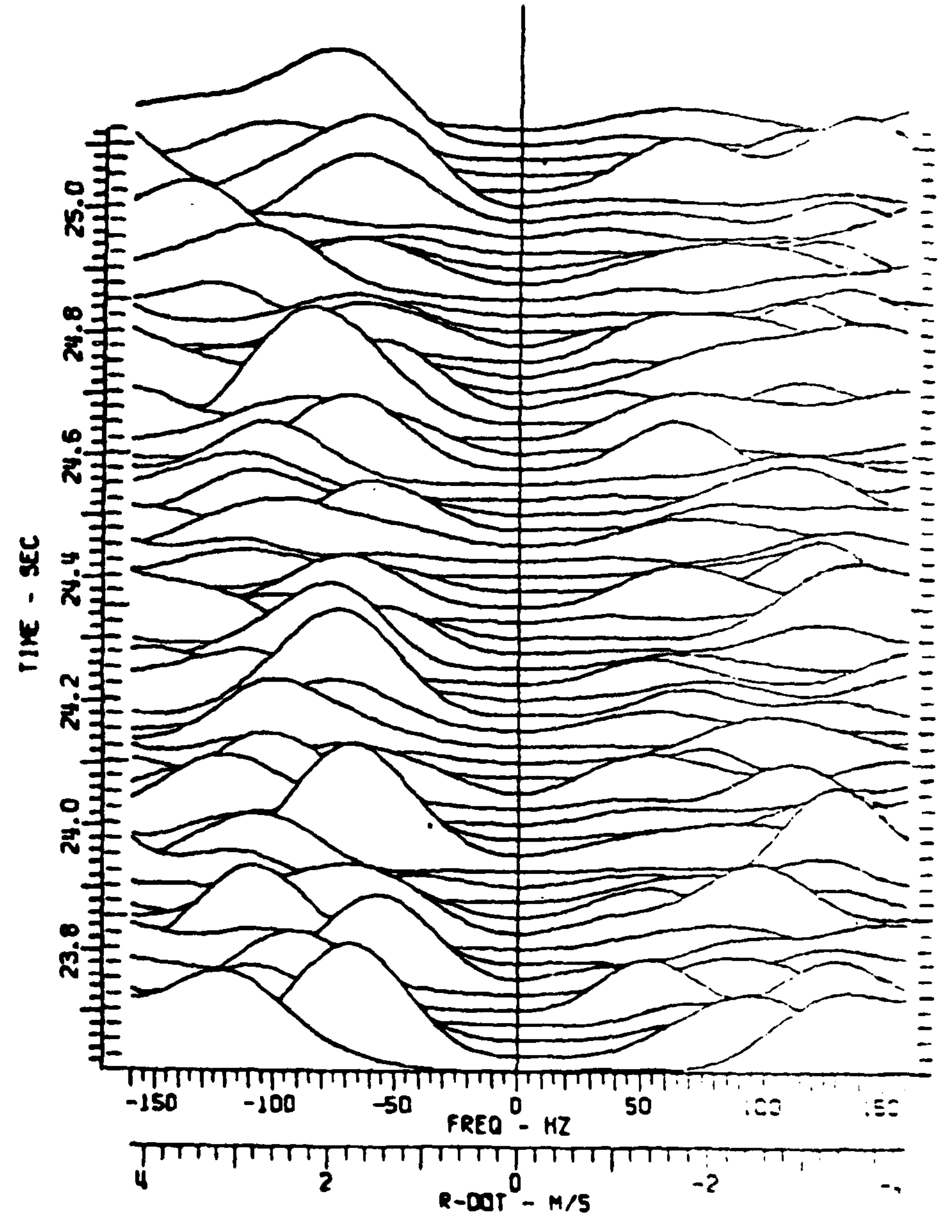

Figure 5(m). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

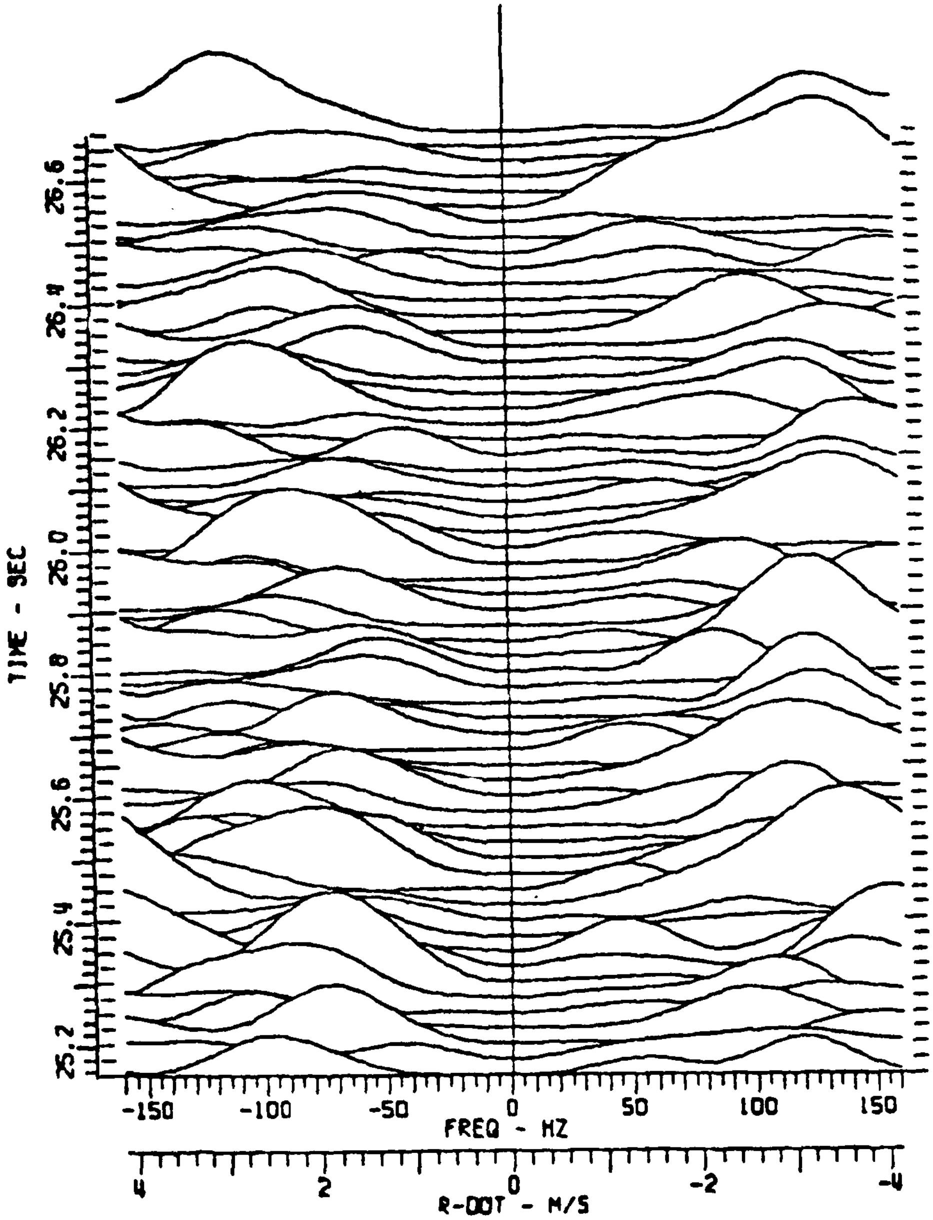

Figure 5(n). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

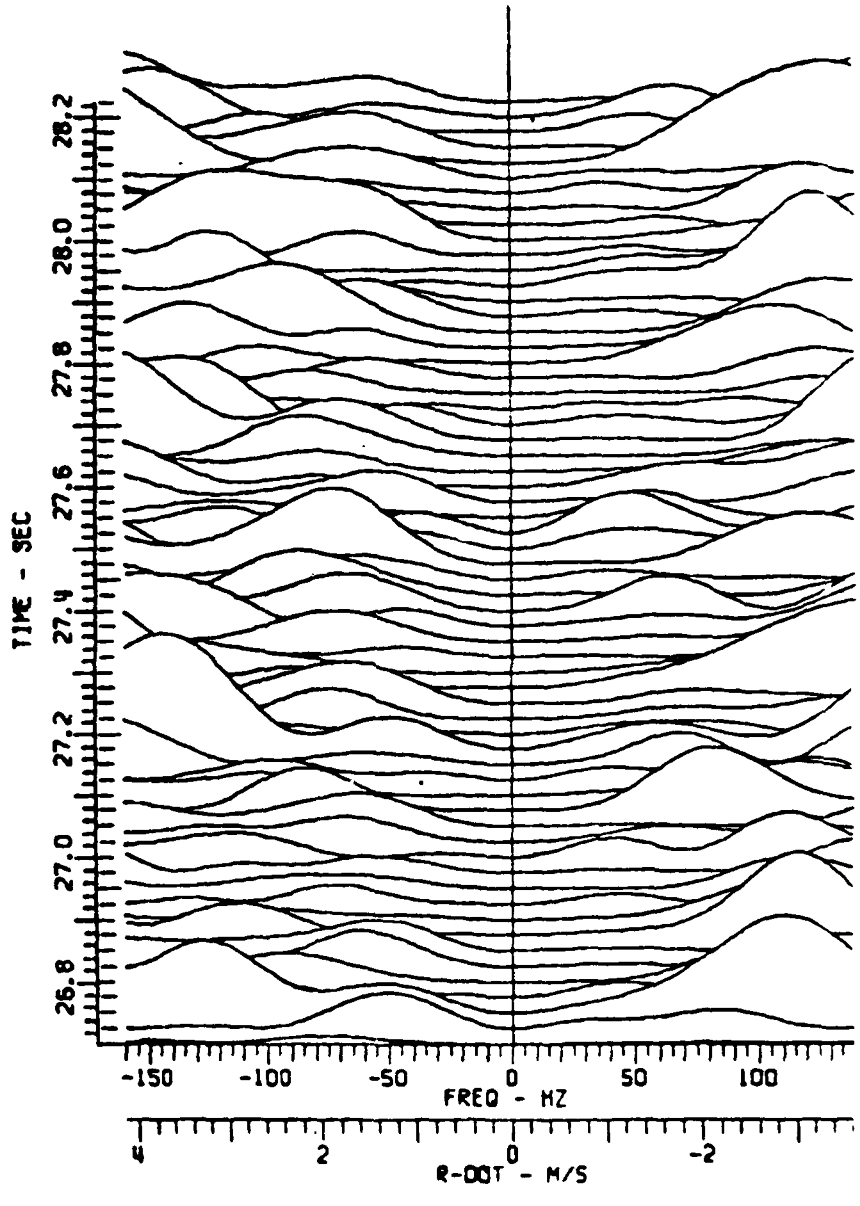

Figure 5(o). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

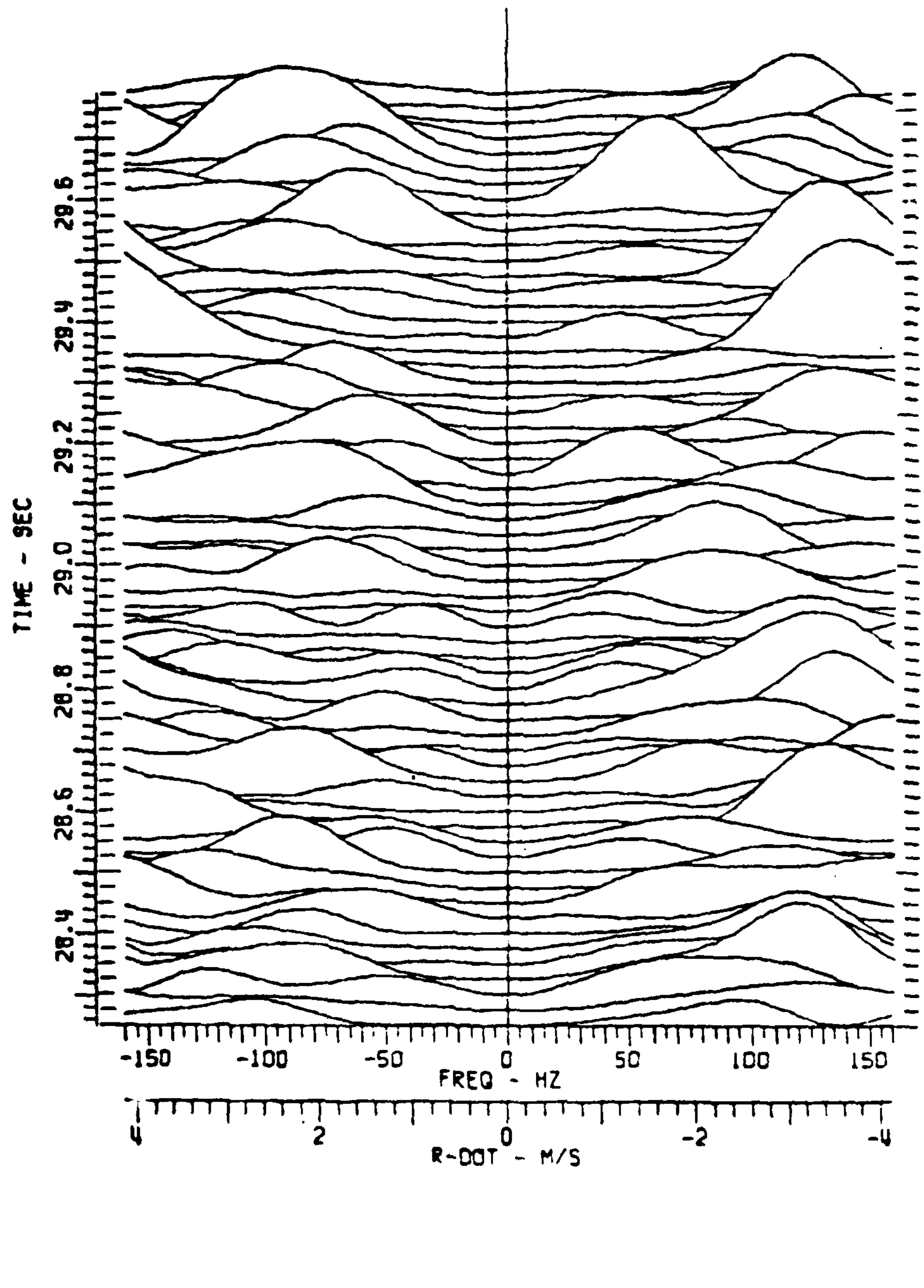

Figure 5(p). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

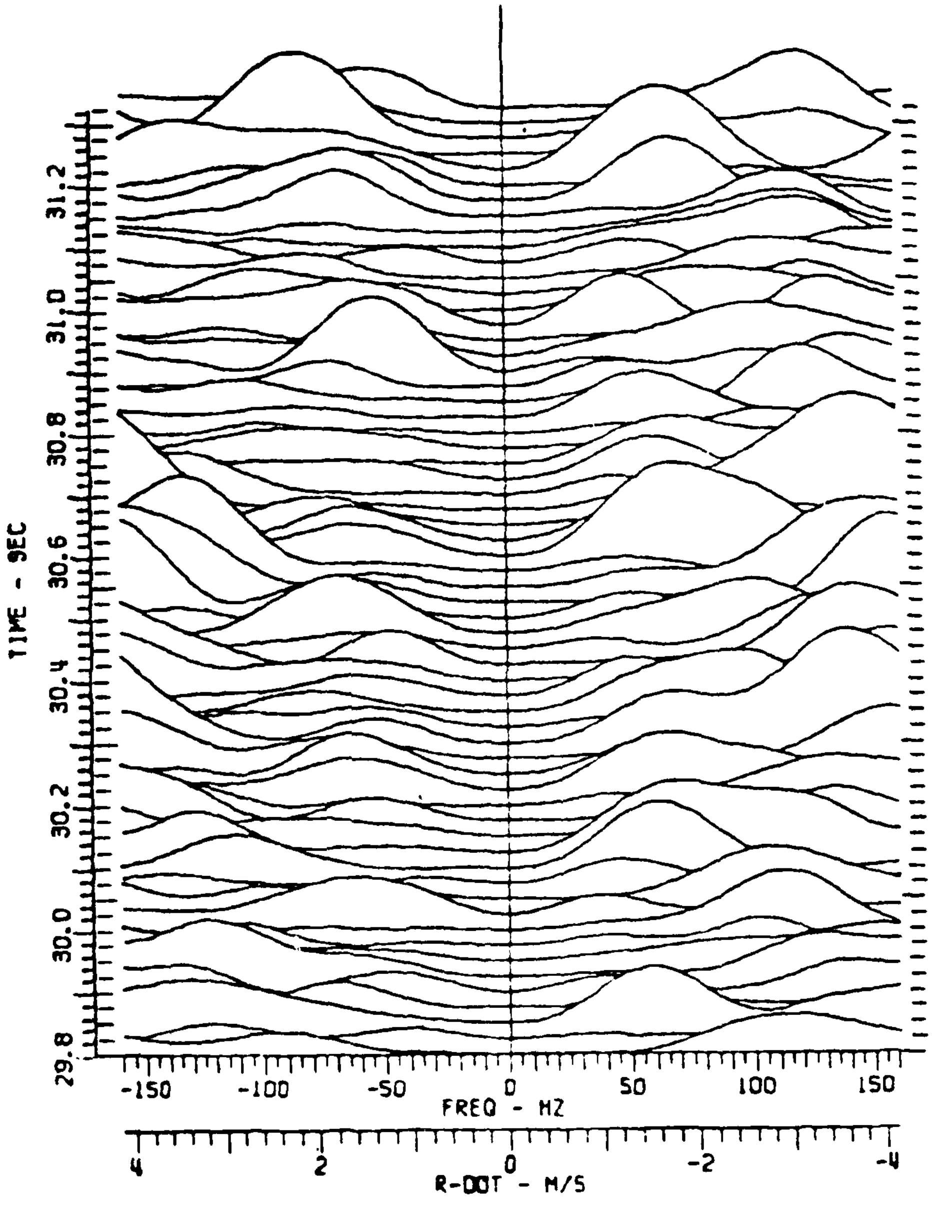

Figure 5(q). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

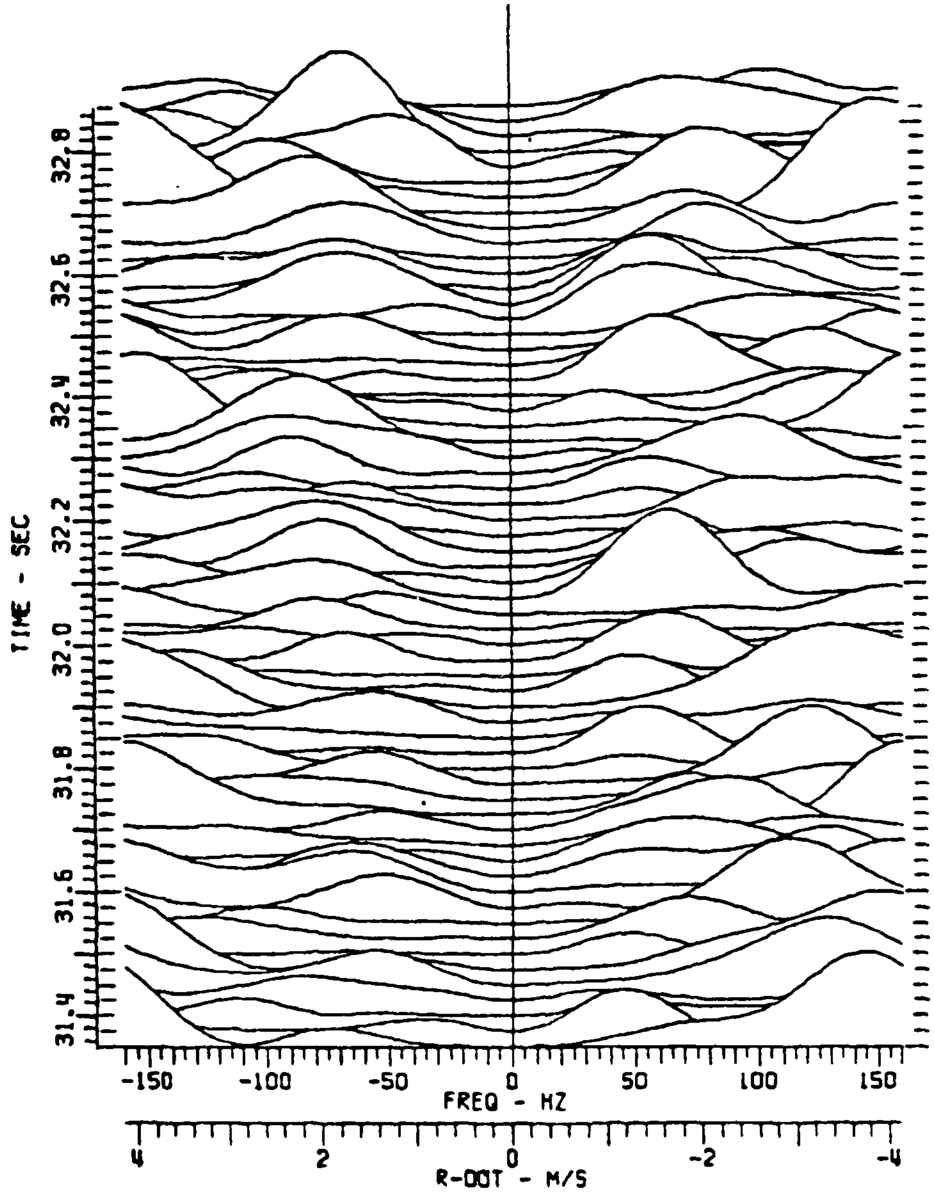

Figure 5(r). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

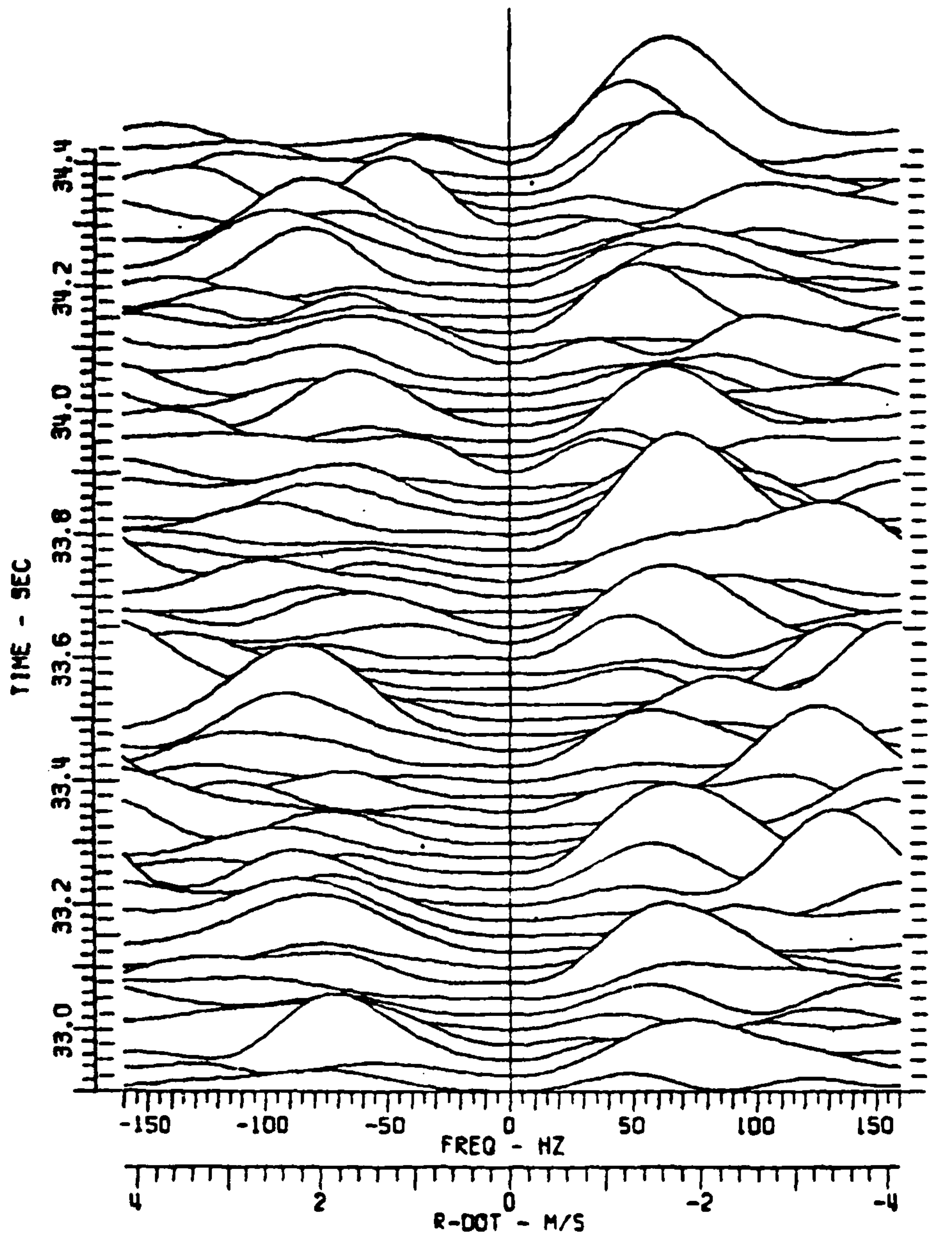

Figure 5(s). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

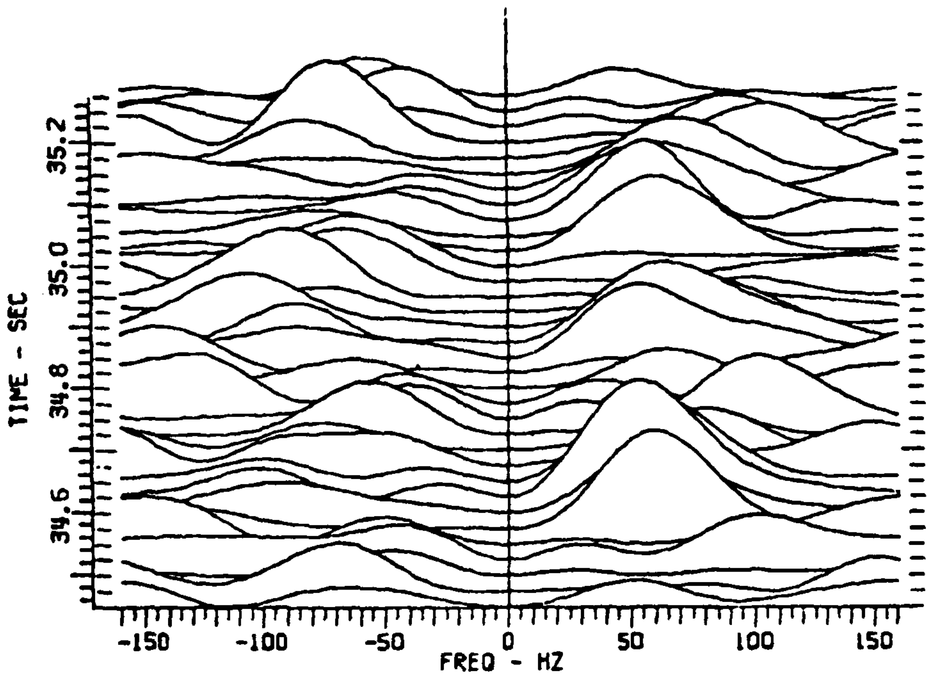

Figure 5(t). Doppler history plot with Fourier transform window equal to 1/5 cycle of spin.

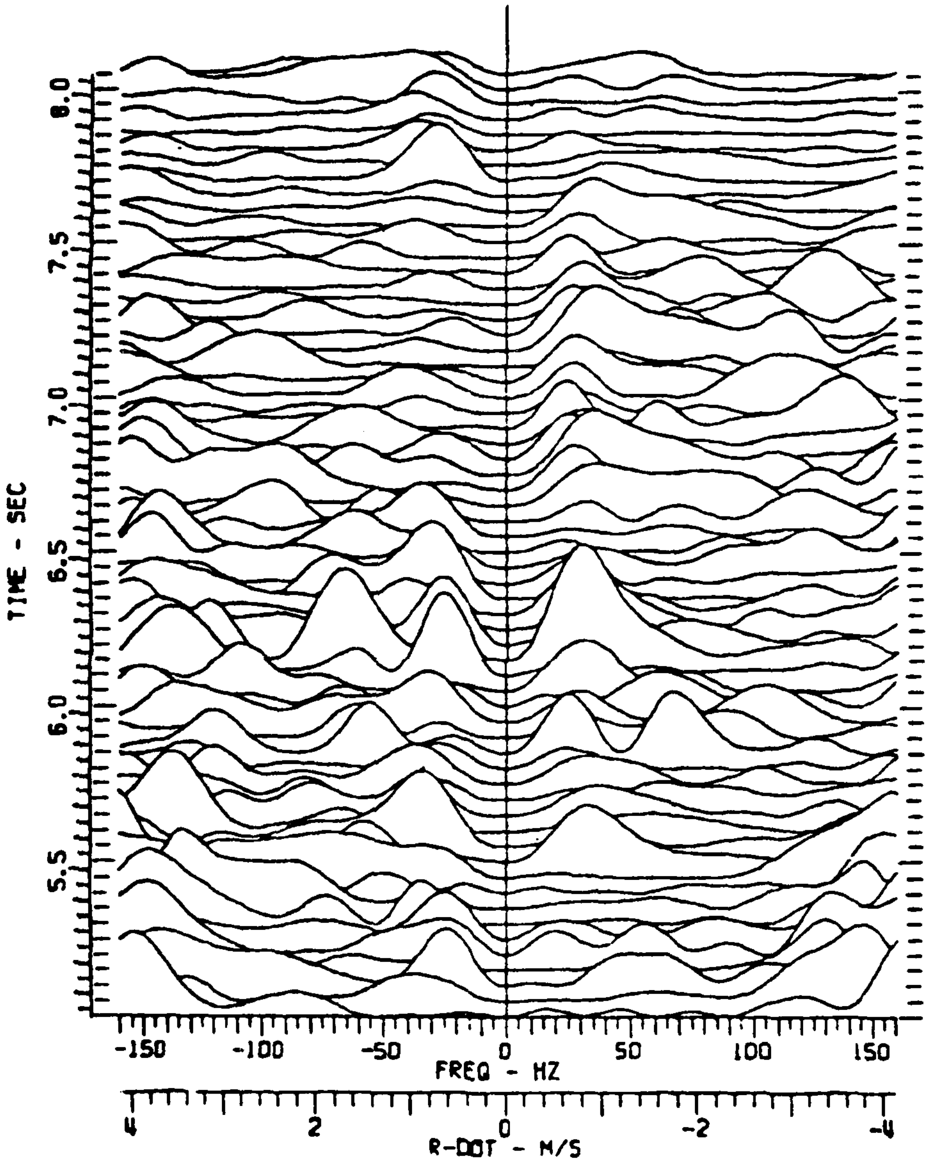

Figure 6(a). Doppler history plot with Fourier transform window equal to 2/5 cycle of spin.

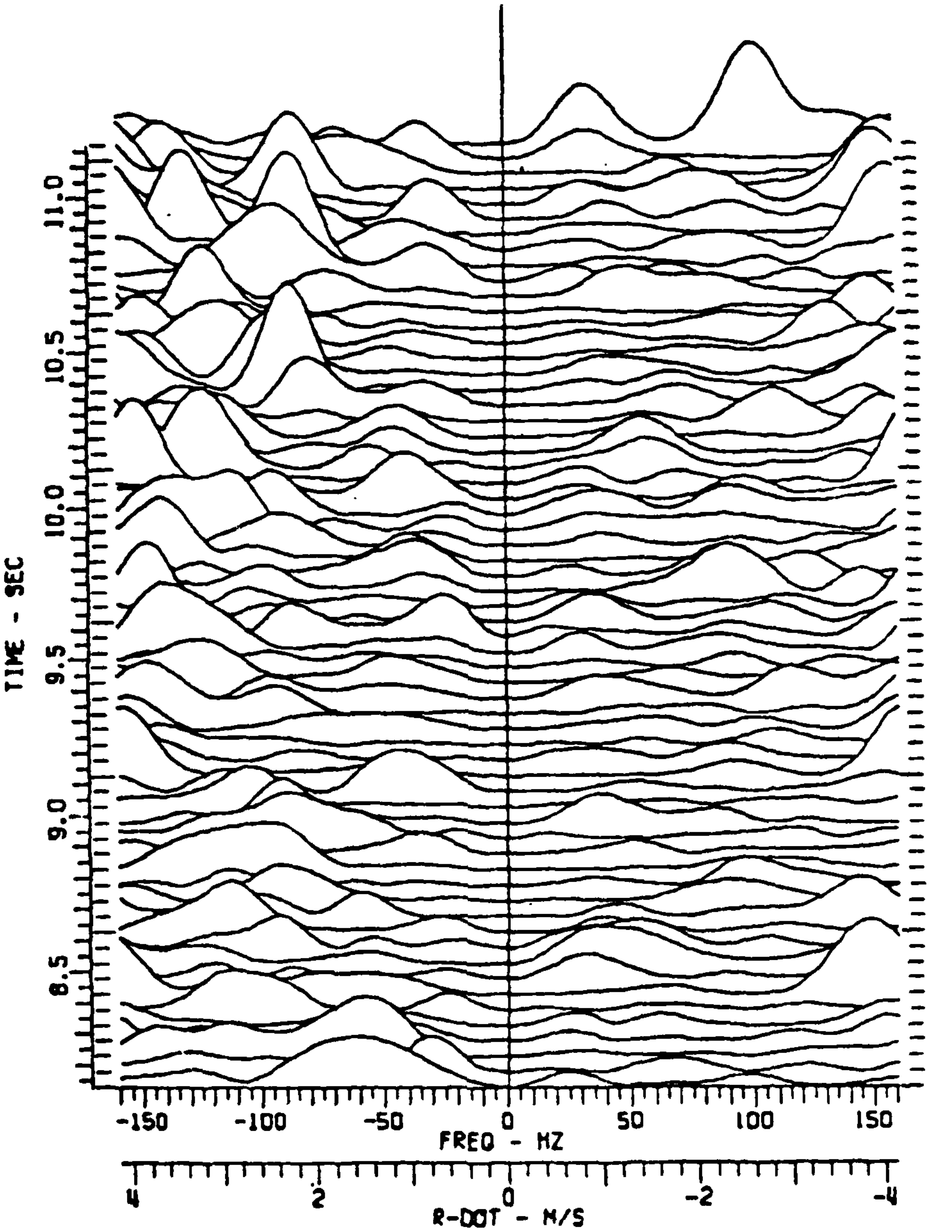

Figure 6(b). Doppler history plot with Fourier transform window equal to 2/5 cycle of spin.

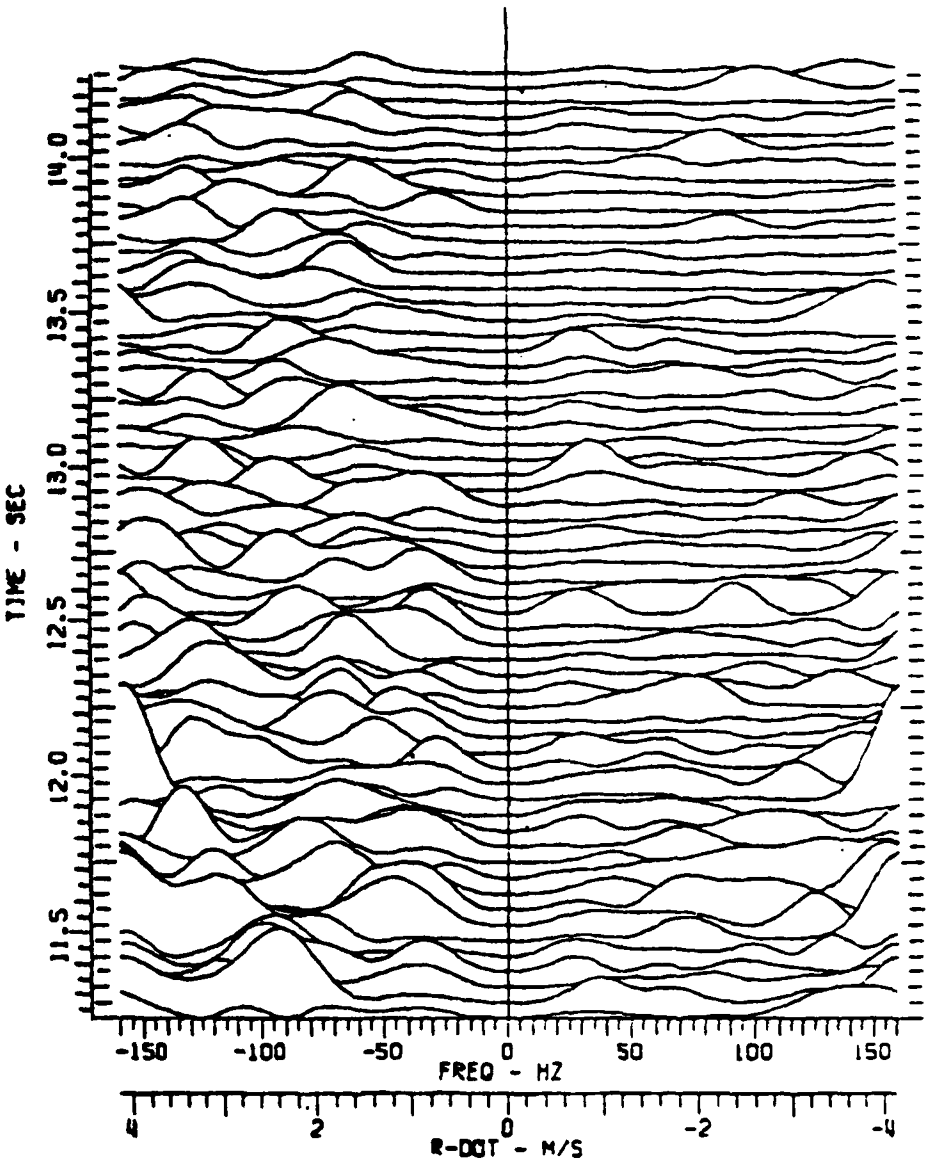

Figure 6(c). Doppler history plot with Fourier transform window equal to 2/5 cycle of spin.

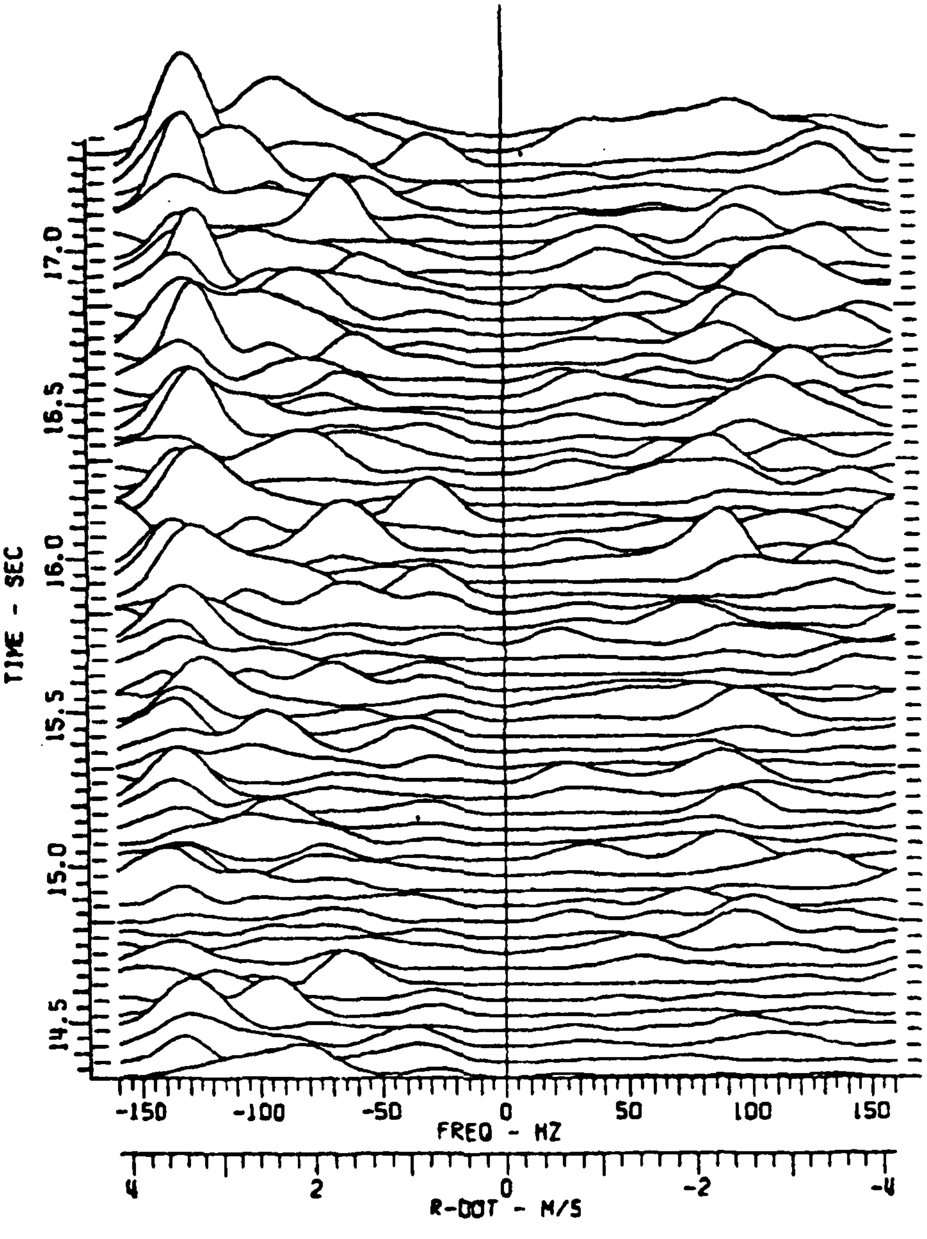

Figure 6(d). Doppler history plot with Fourier transform window equal to 2/5 cycle of spin.

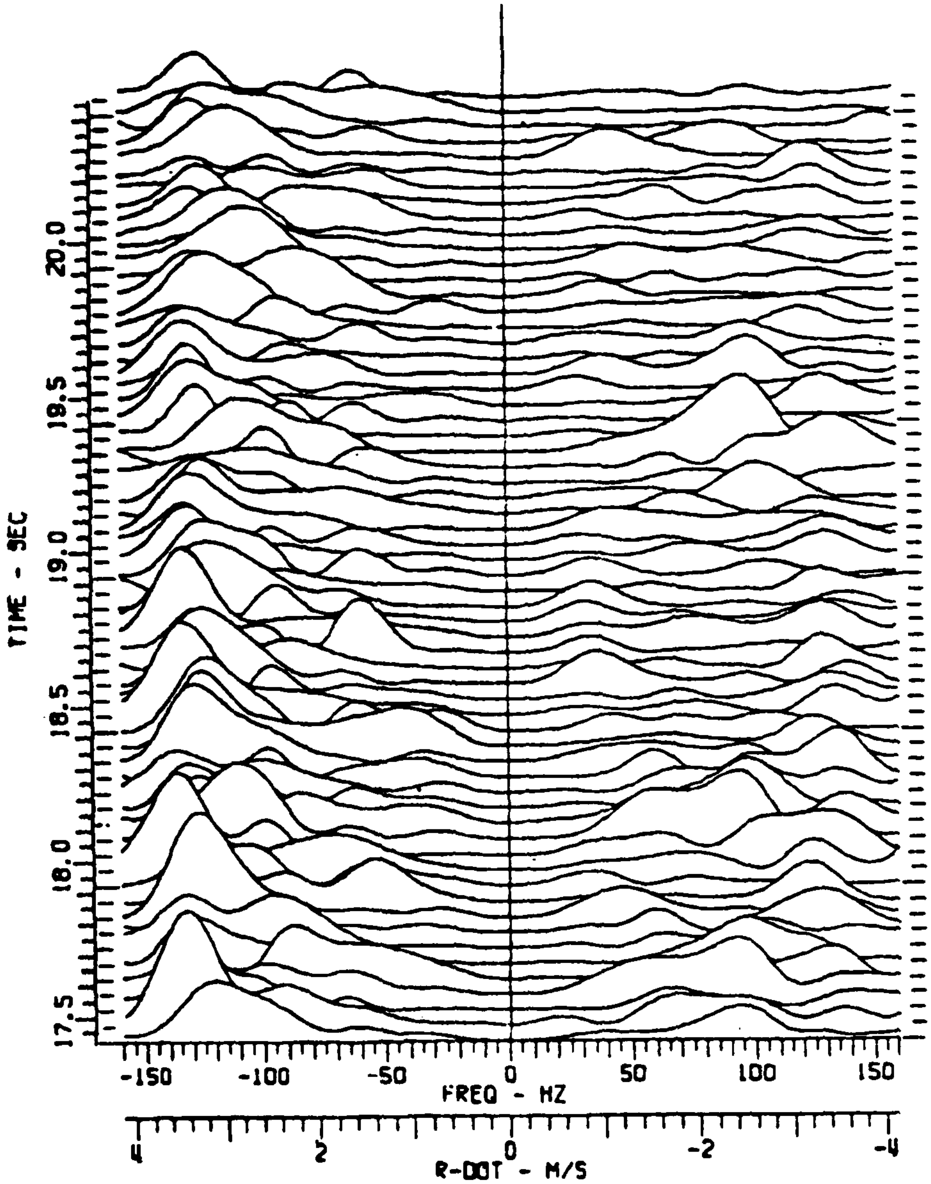

Figure 6(e). Doppler history plot with Fourier transform window equal to 2/5 cycle of spin.

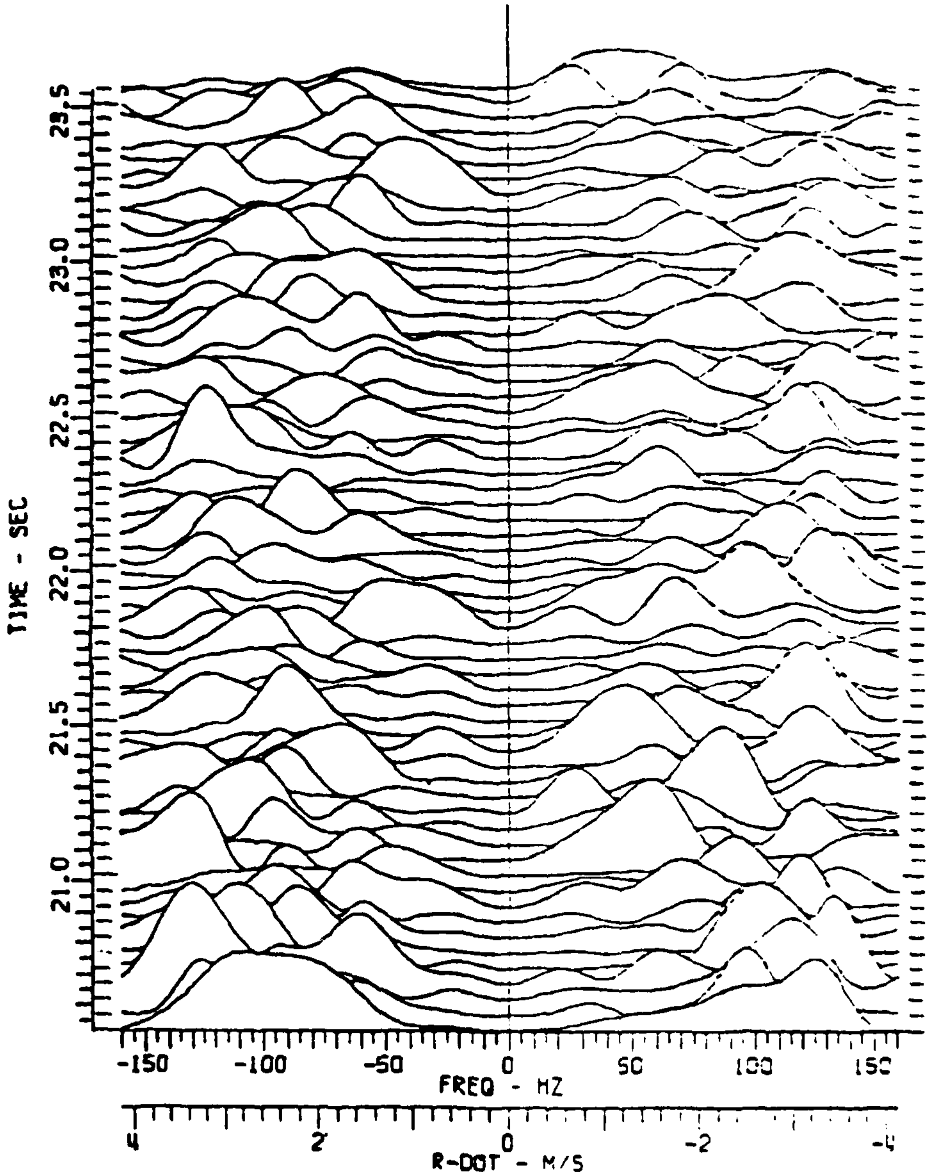

Figure 6(f). Doppler history plot with Fourier transform window equal to 2/5 cycle of spin.

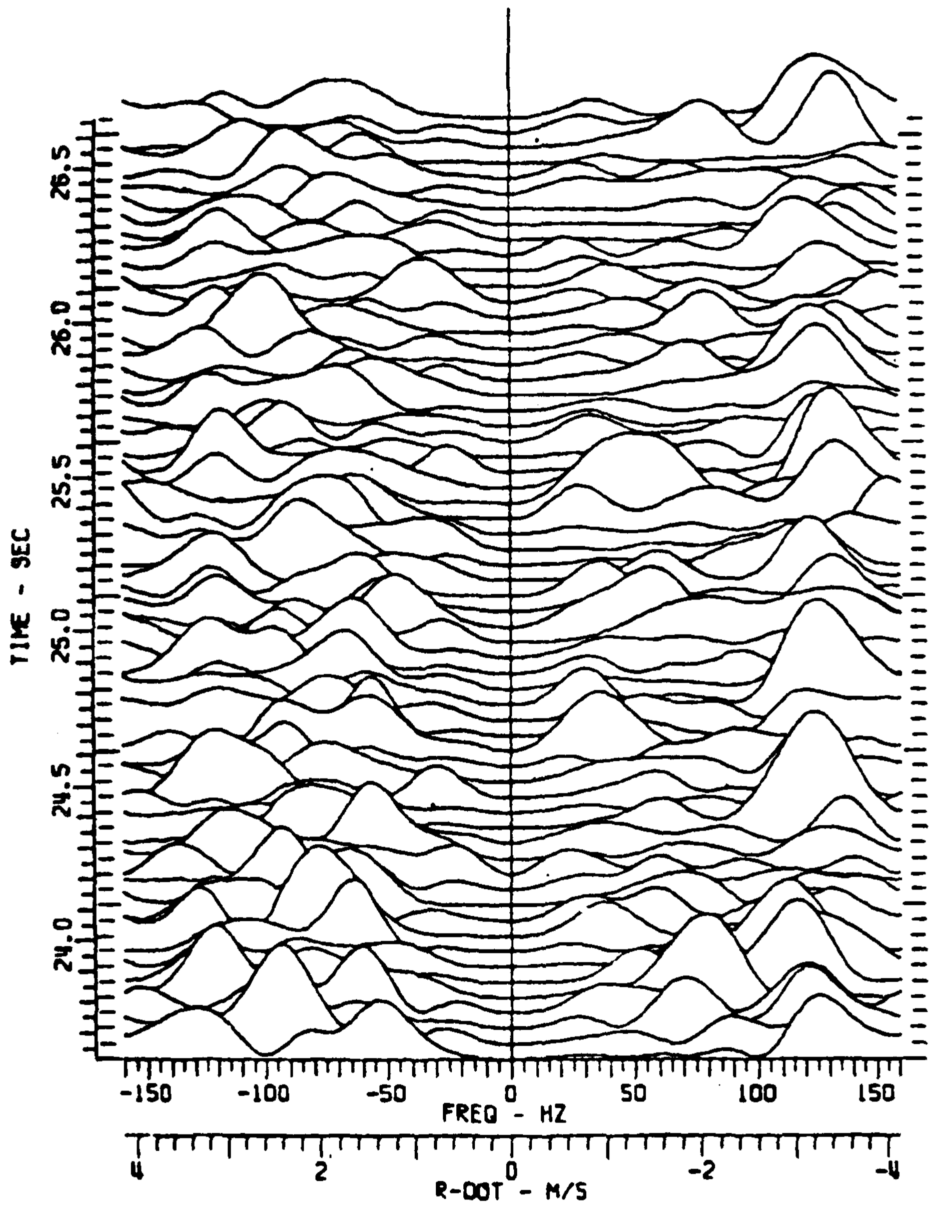

Figure 6(g). Doppler history plot with Fourier transform window equal to 2/5 cycle of spin.

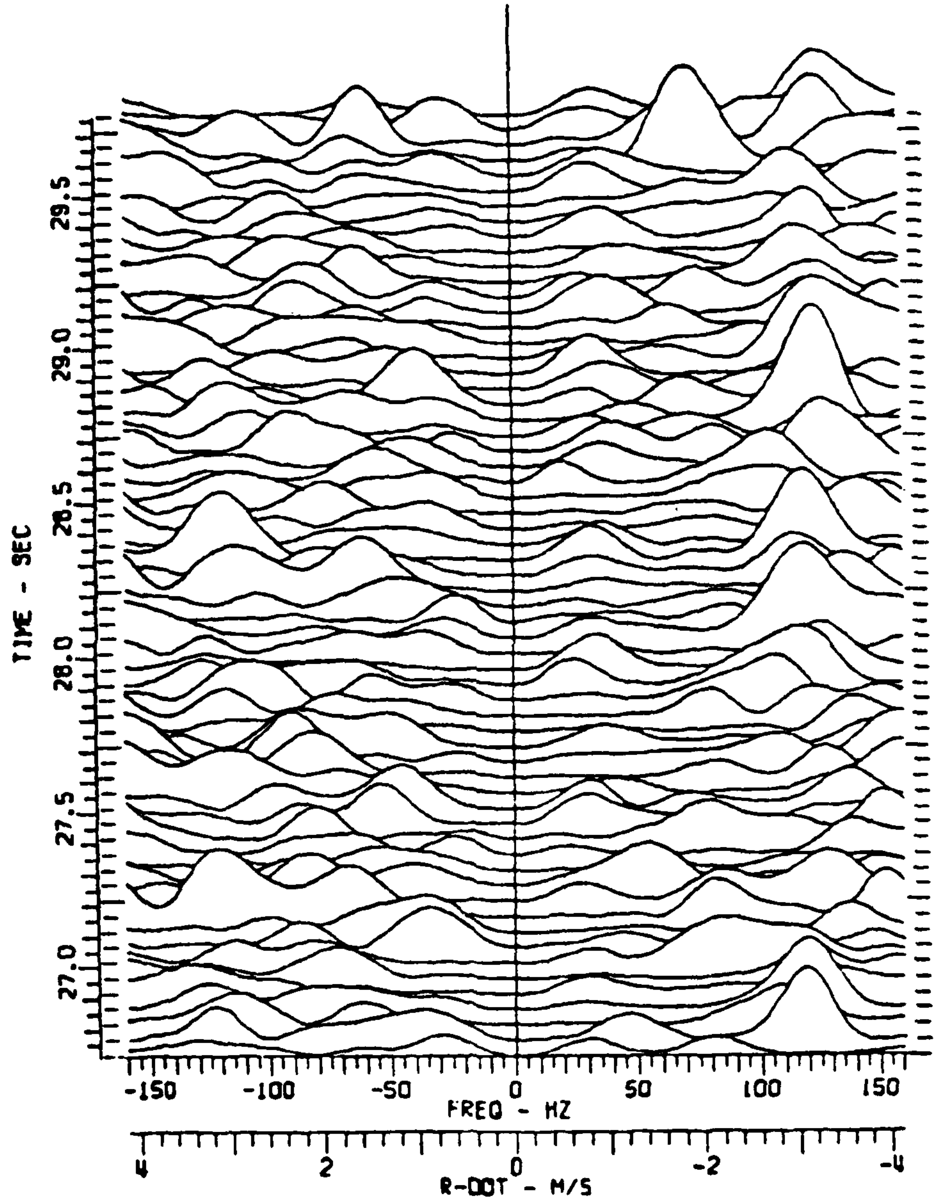

Figure 6(h). Doppler history plot with Fourier transform window equal to 2/5 cycle of spin.

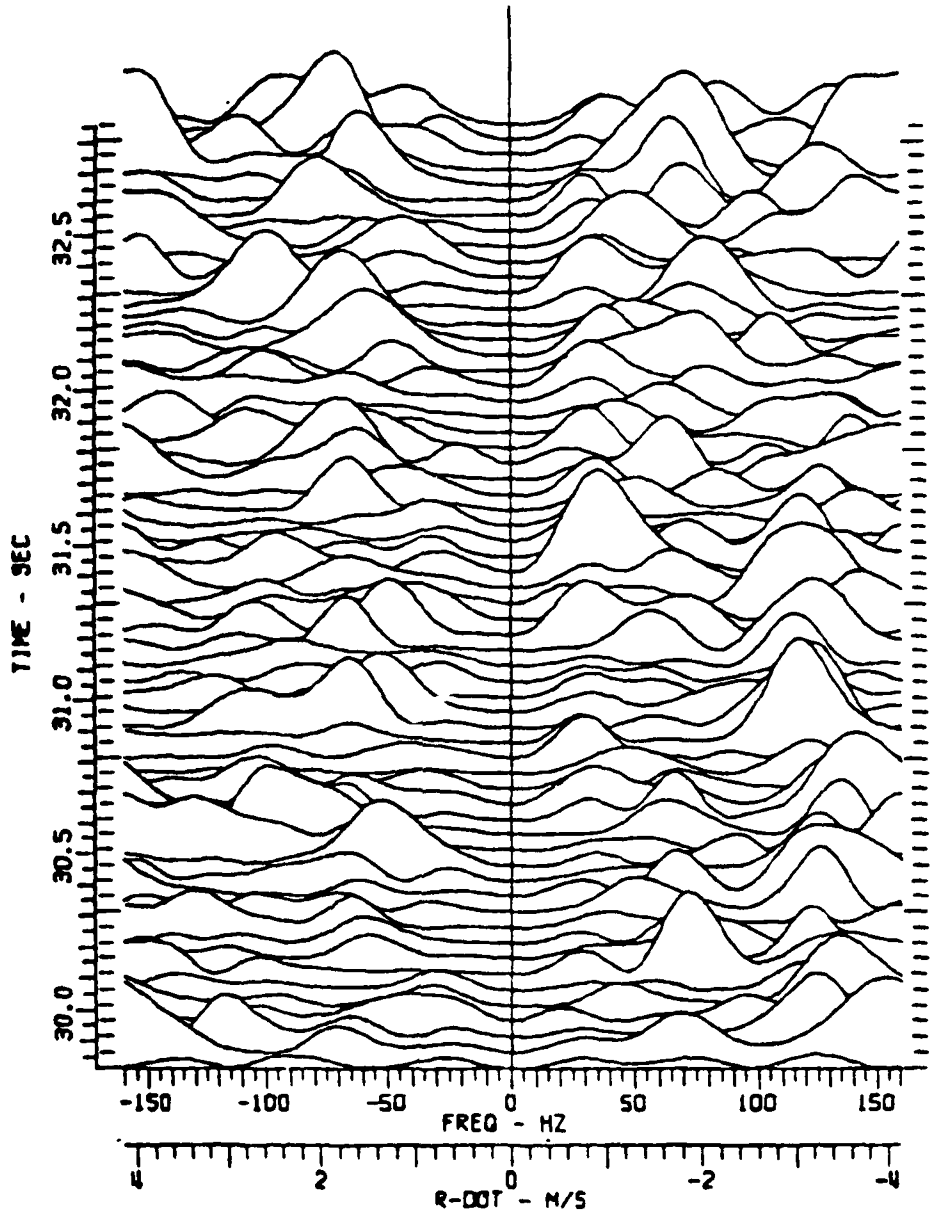

Figure 6(i). Doppler history plot with Fourier transform window equal to 2/5 cycle of spin.

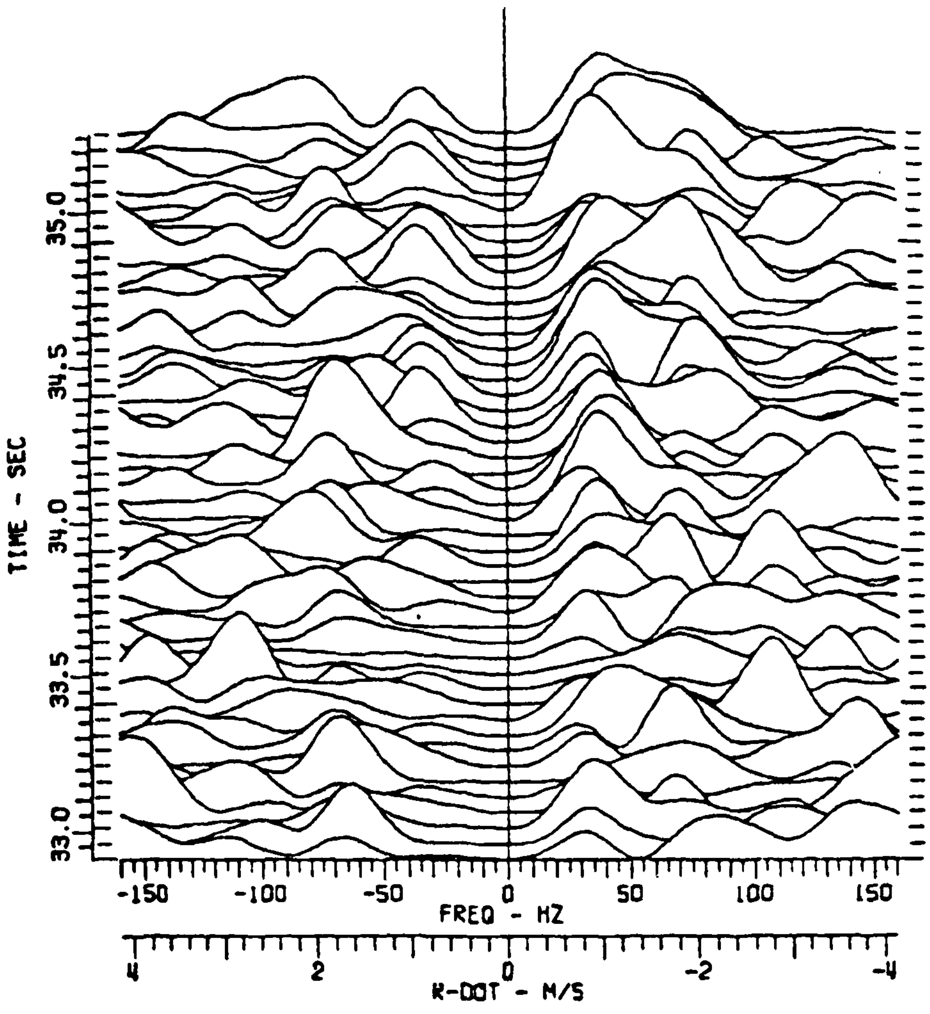

Figure 6(j). Doppler history plot with Fourier transform window equal to 2/5 cycle of spin.

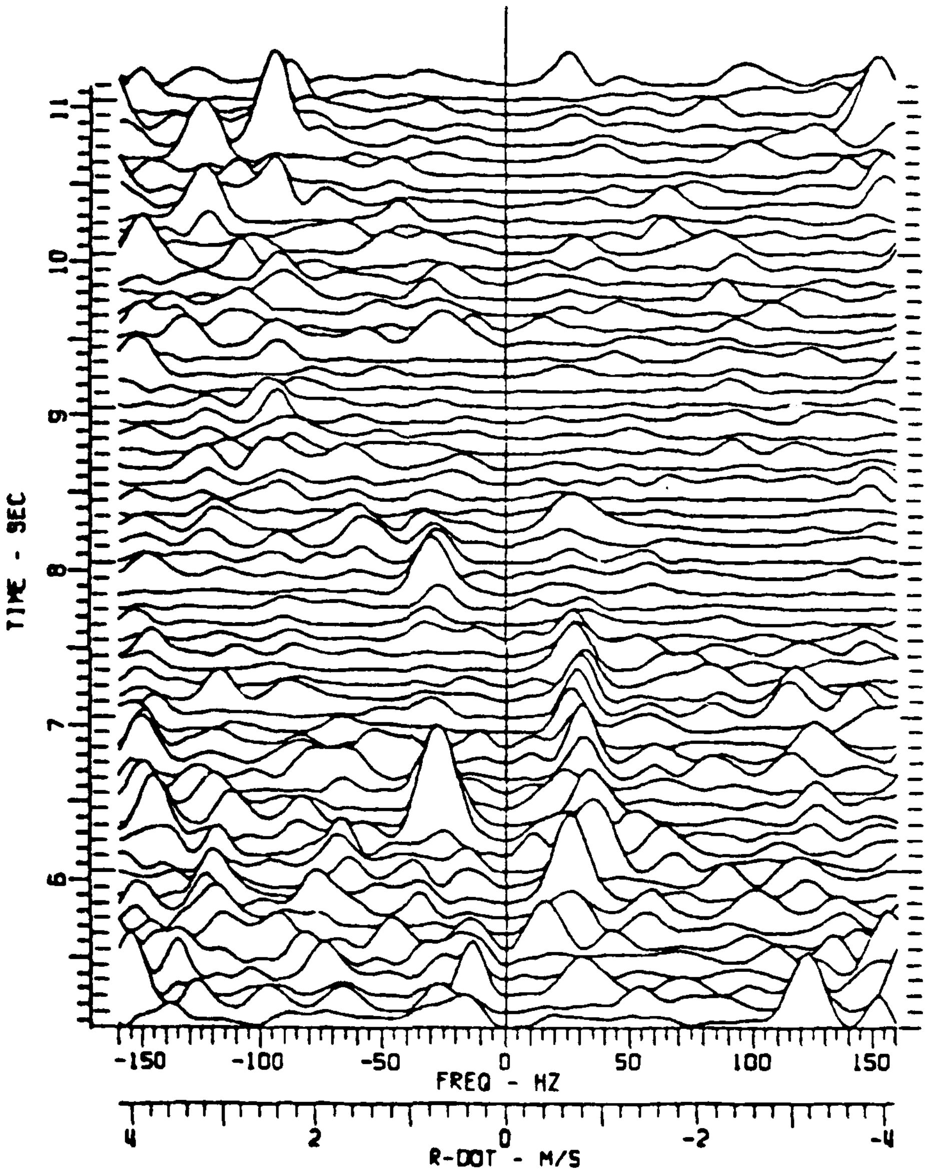

Figure 7(a). Doppler history plot with Fourier transform window equal to 4/5 cycle of spin.

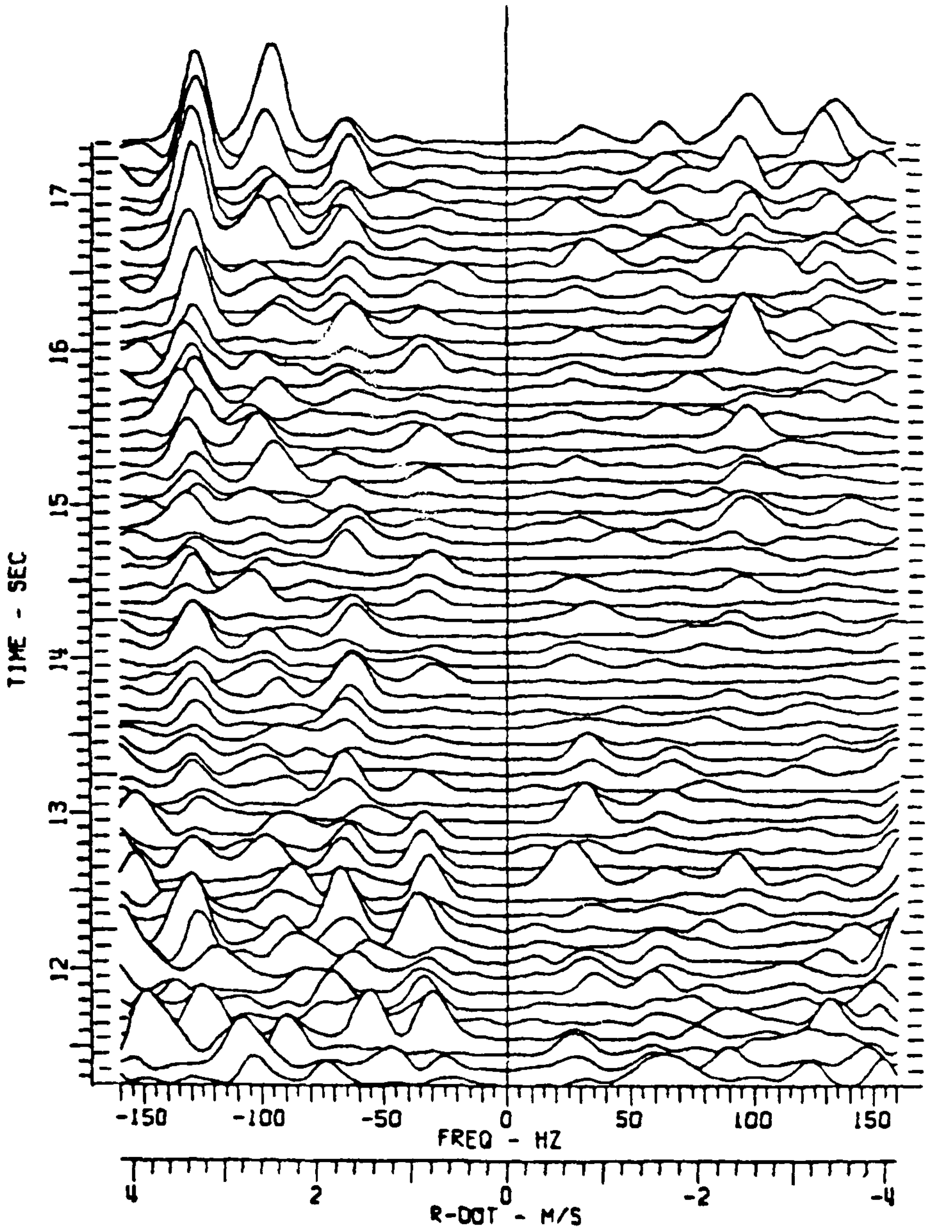

Figure 7(b). Doppler history plot with Fourier transform window equal to 4/5 cycle of spin.

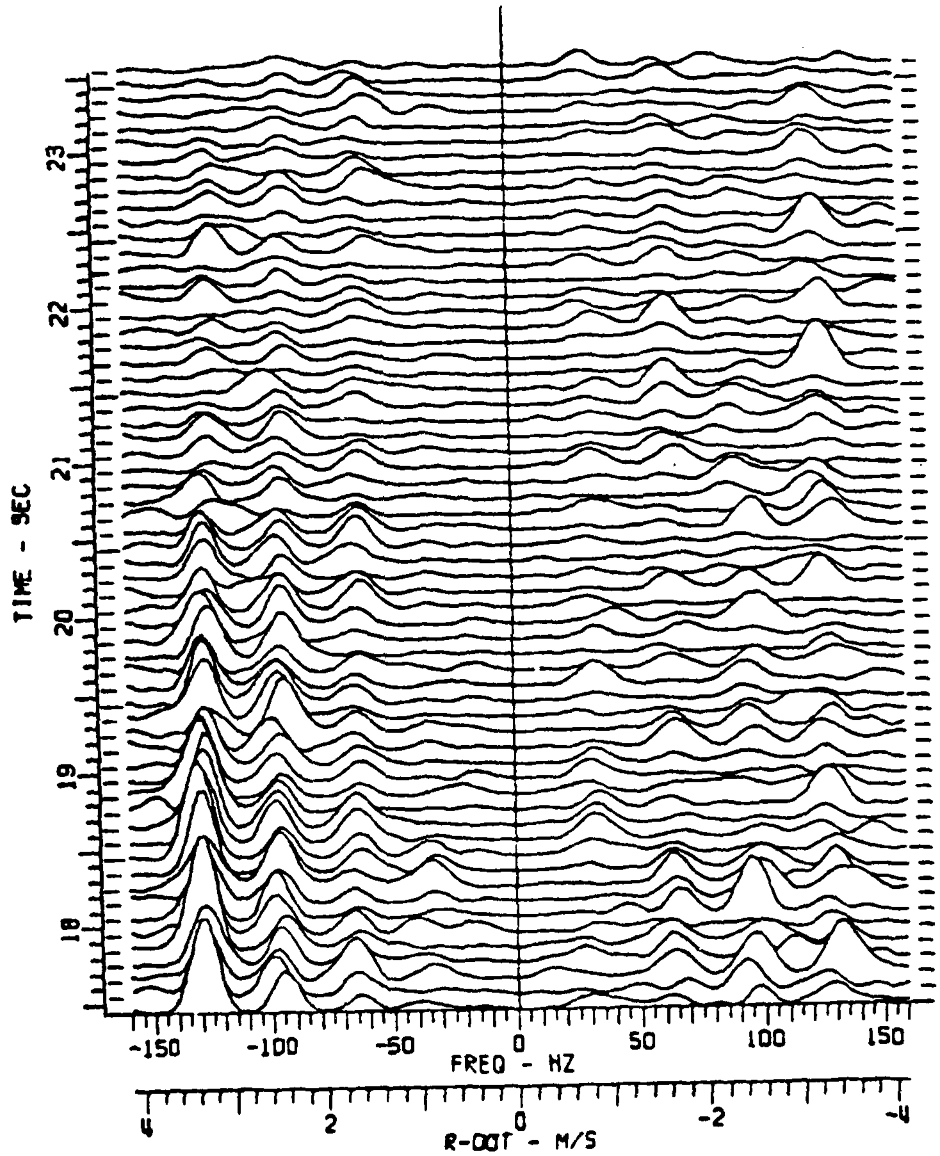

Figure 7(c). Doppler history plot with Fourier transform window equal to 4/5 cycle of spin.

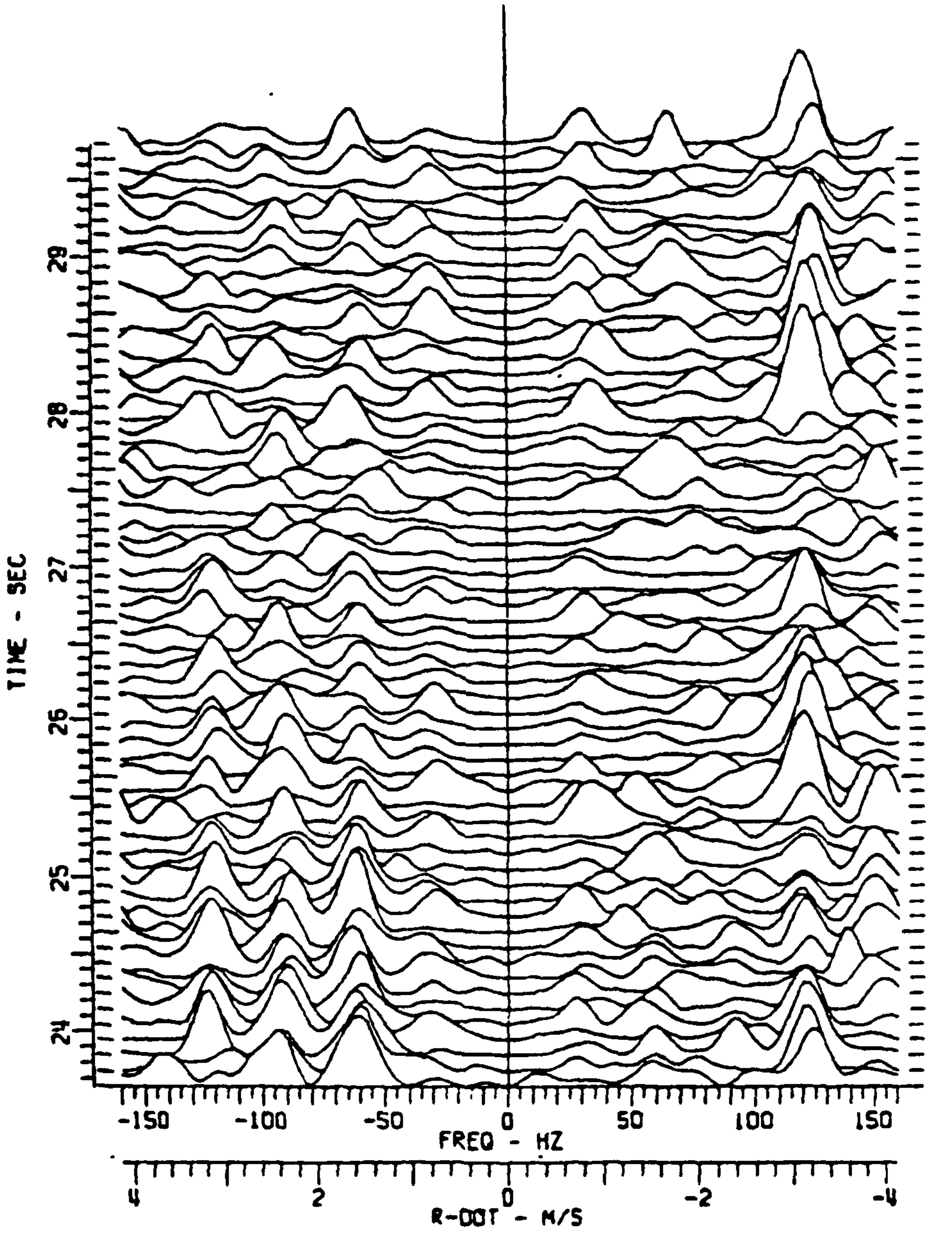

Figure 7(d). Doppler history plot with Fourier transform window equal to 4/5 cycle of spin.

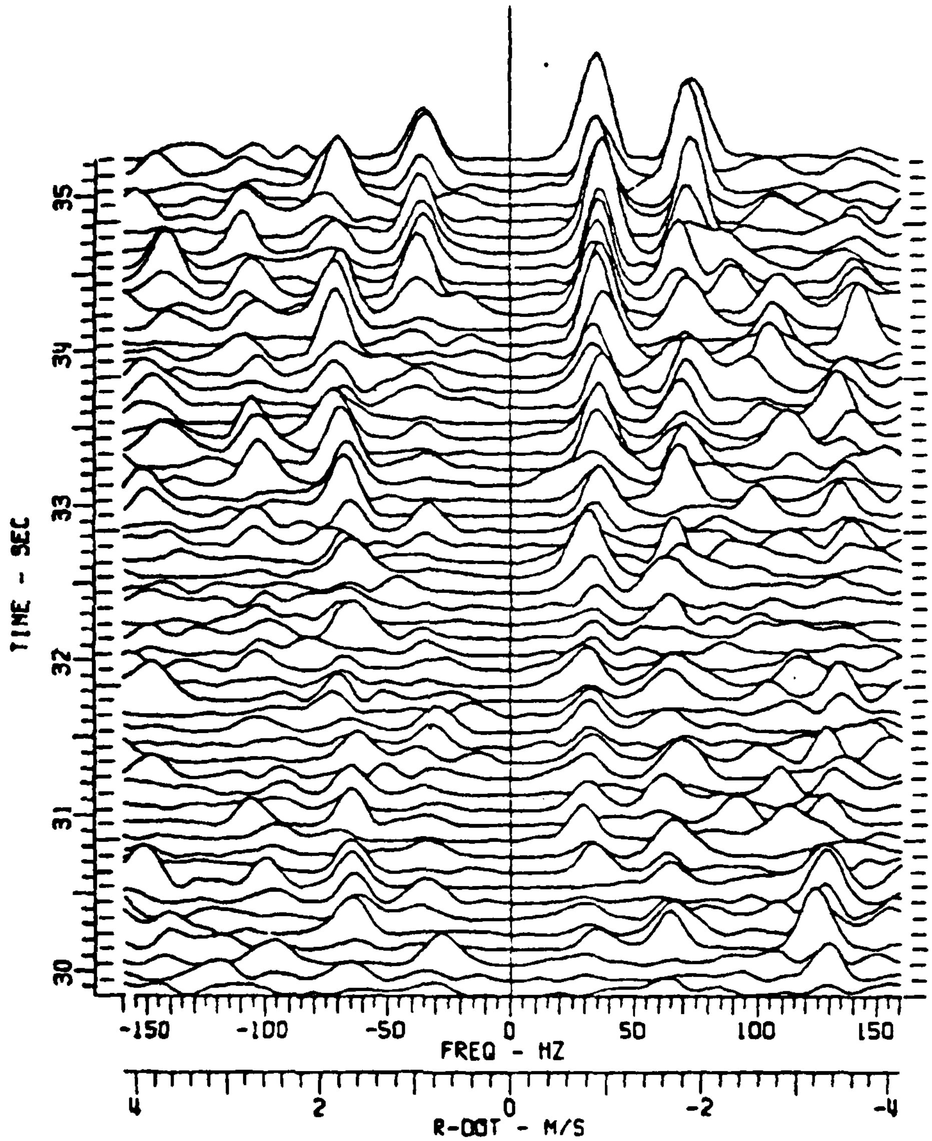

Figure 7(e). Doppler history plot with Fourier transform window equal to 4/5 cycle of spin.

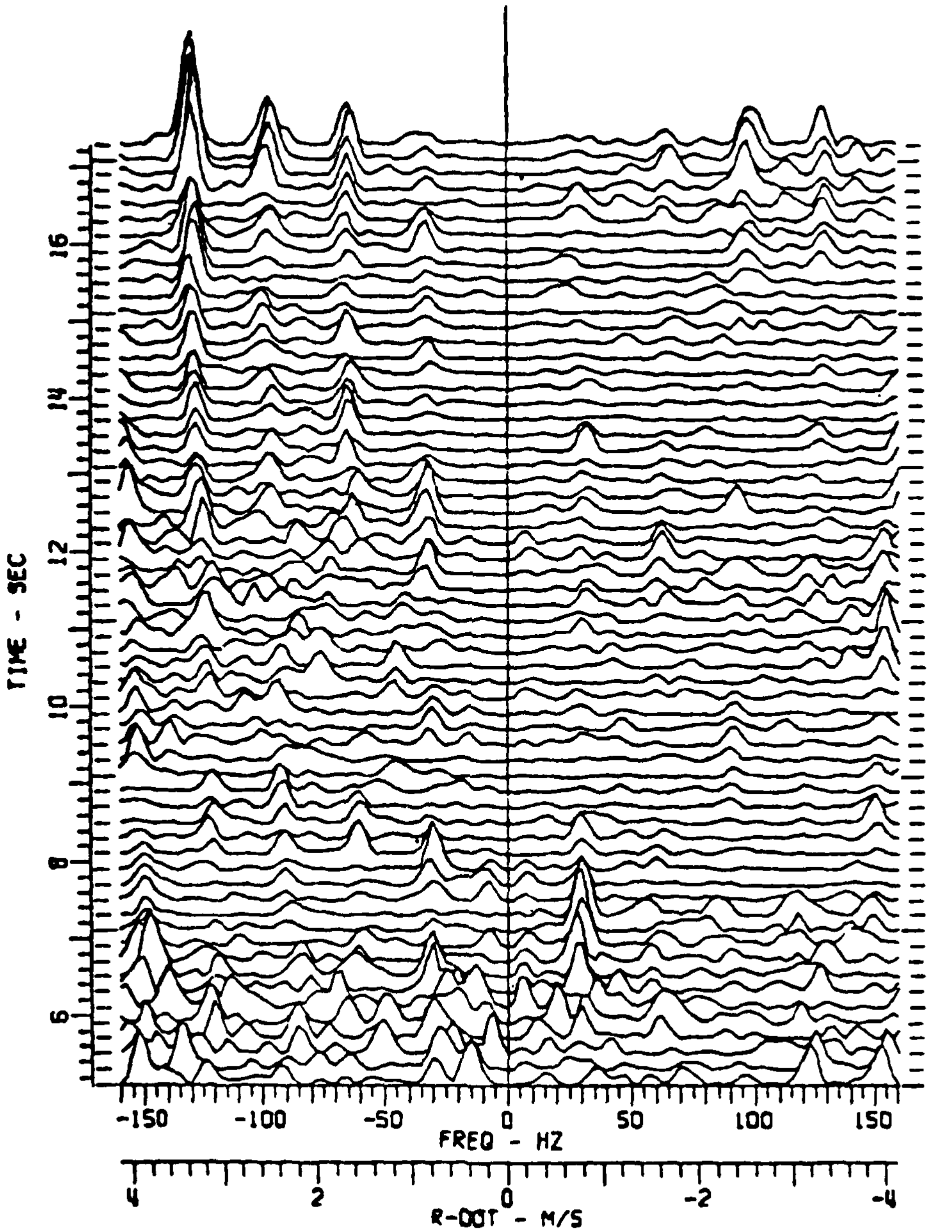

Figure 8(a). Doppler history plot with Fourier transform window equal to 8/5 cycle of spin.

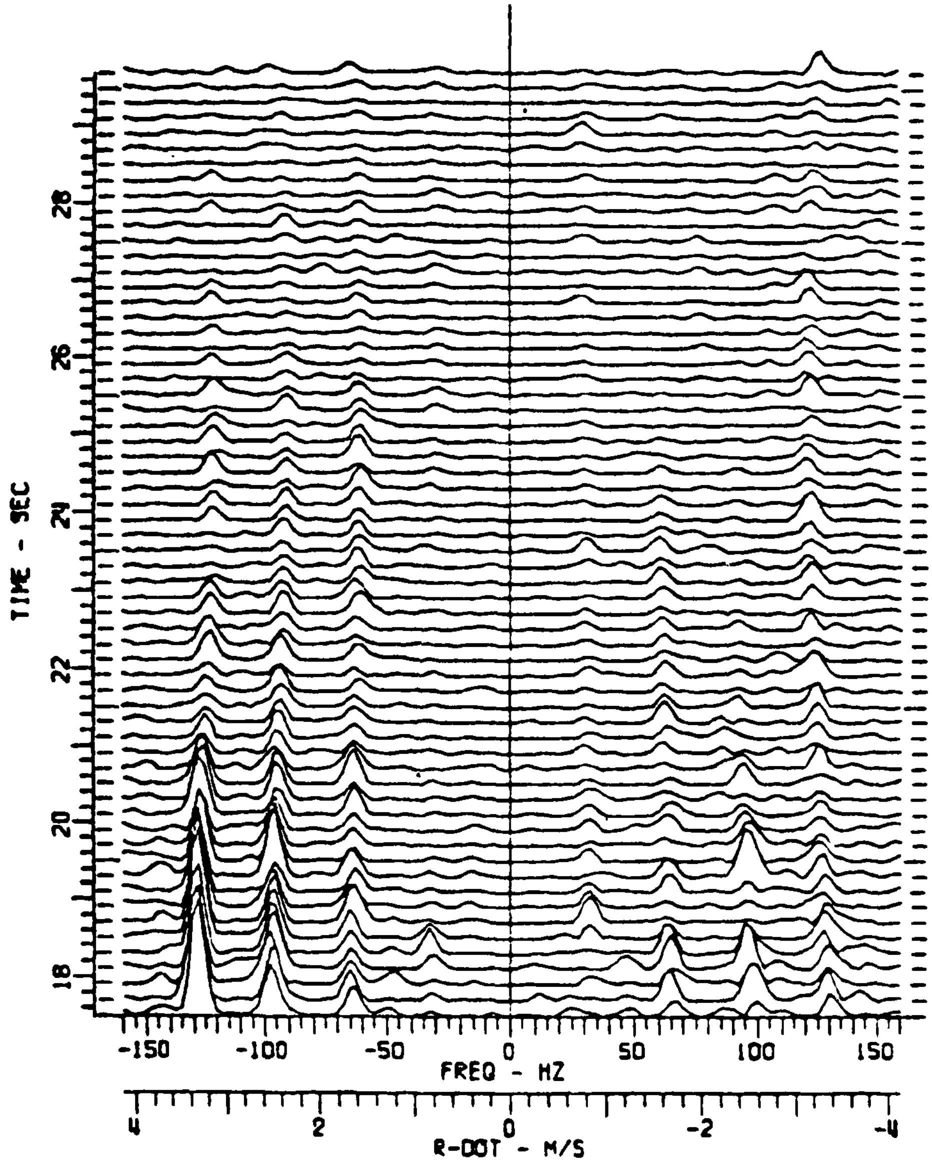

Figure 8(b). Doppler history plot with Fourier transform window equal to 8/5 cycle of spin.

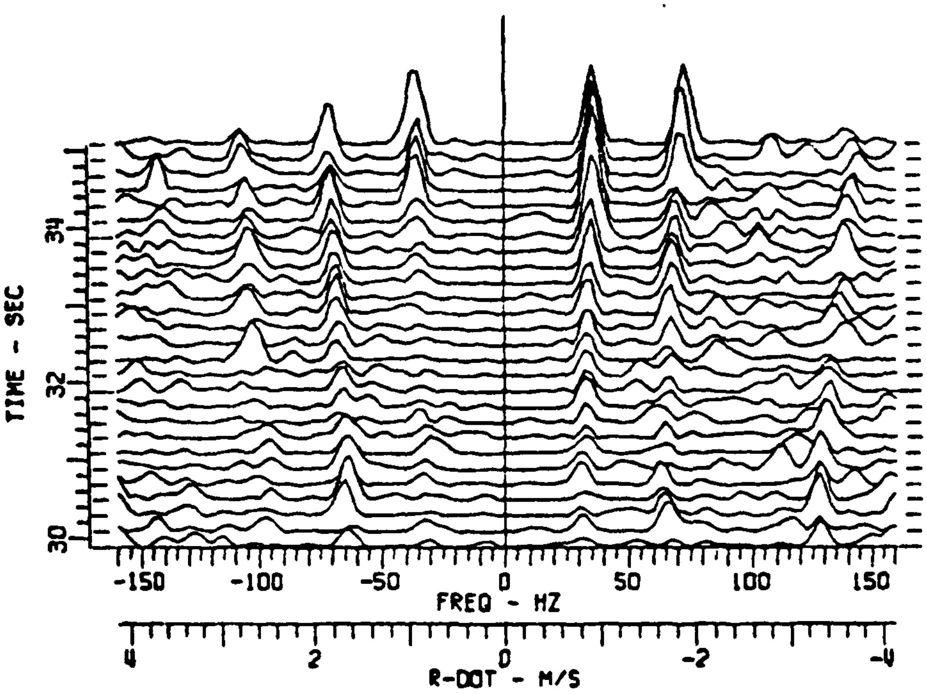

Figure 8(c). Doppler history plot with Fourier transform window equal to 8/5 cycle of spin.

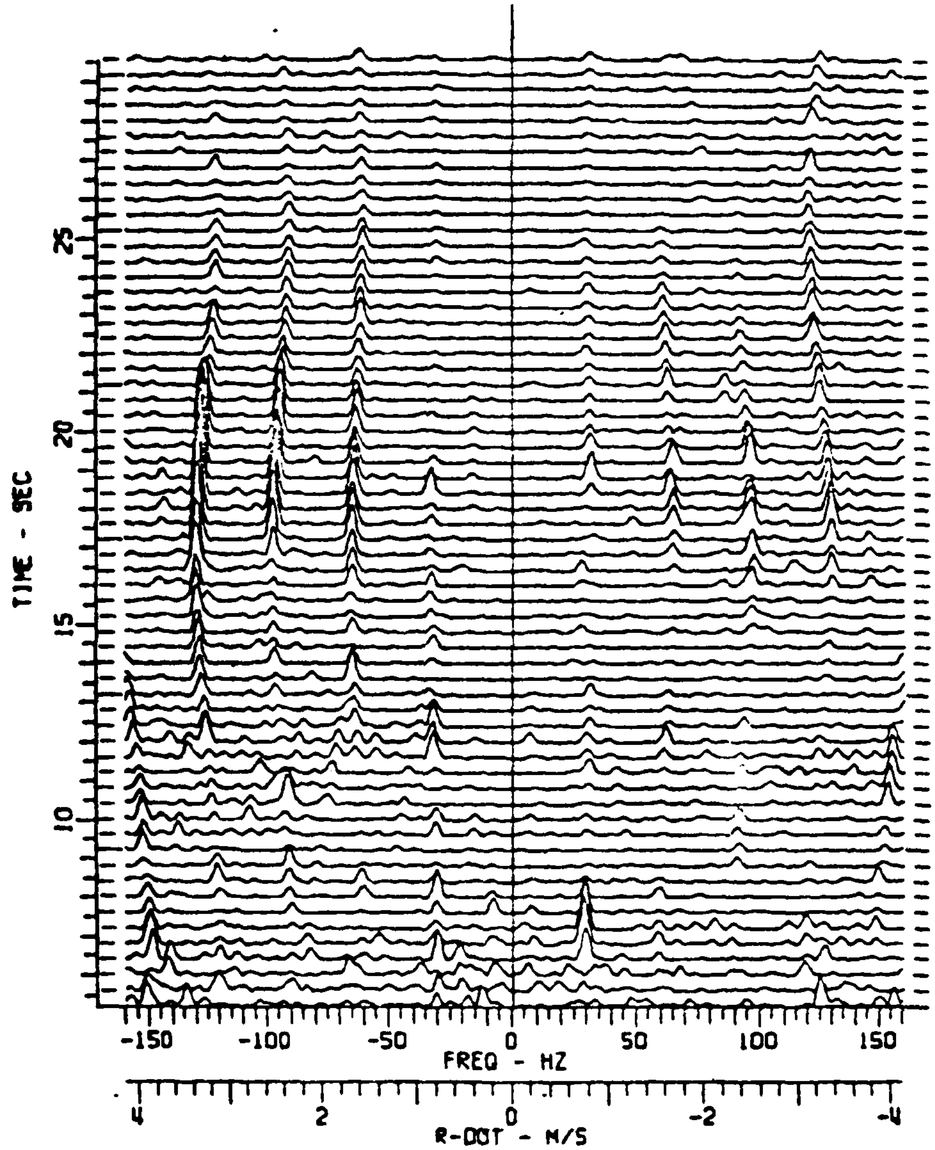

Figure 9(a). Doppler history plot with Fourier transform window equal to 16/5 cycle of spin.

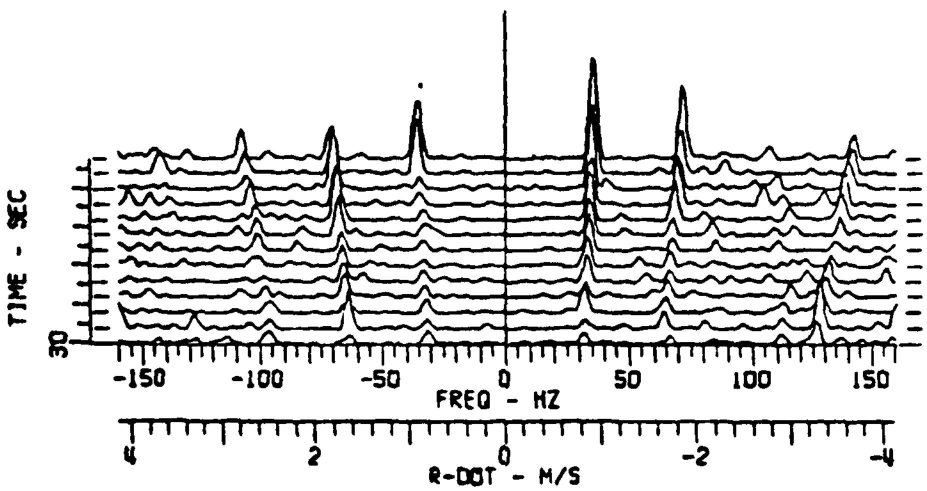

Figure 9(b). Doppler history plot with Fourier transform window equal to 16/5 cycle pf spin.

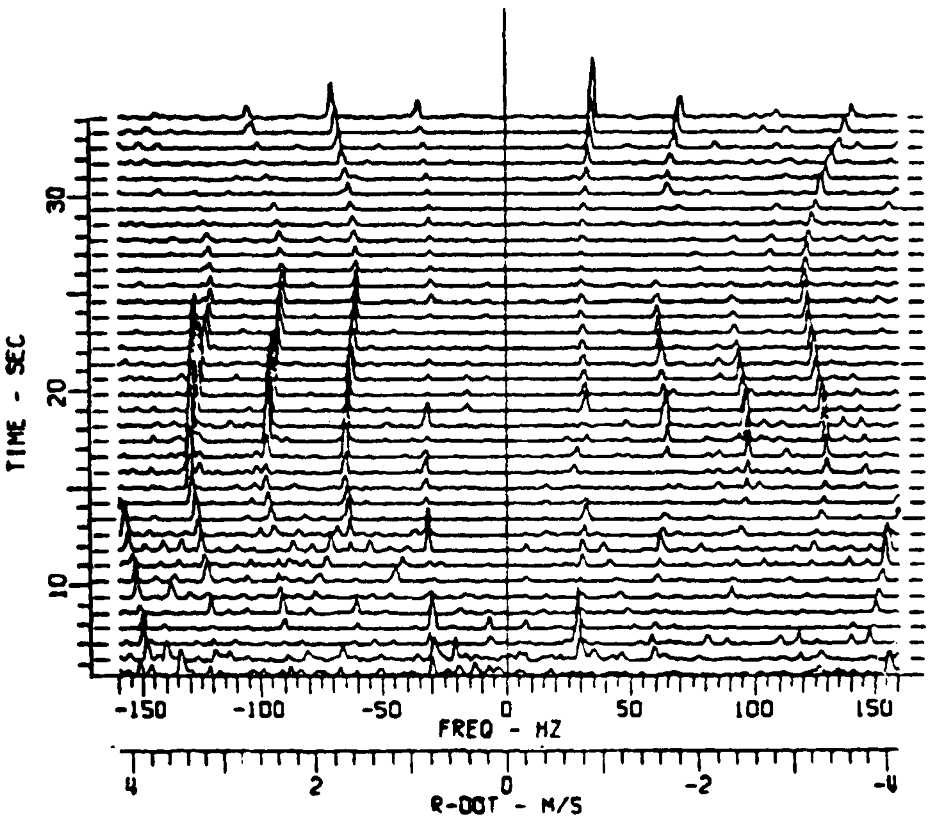

Figure 10. Doppler history plot with Fourier transform window equal to 32/5 cycle of spin.

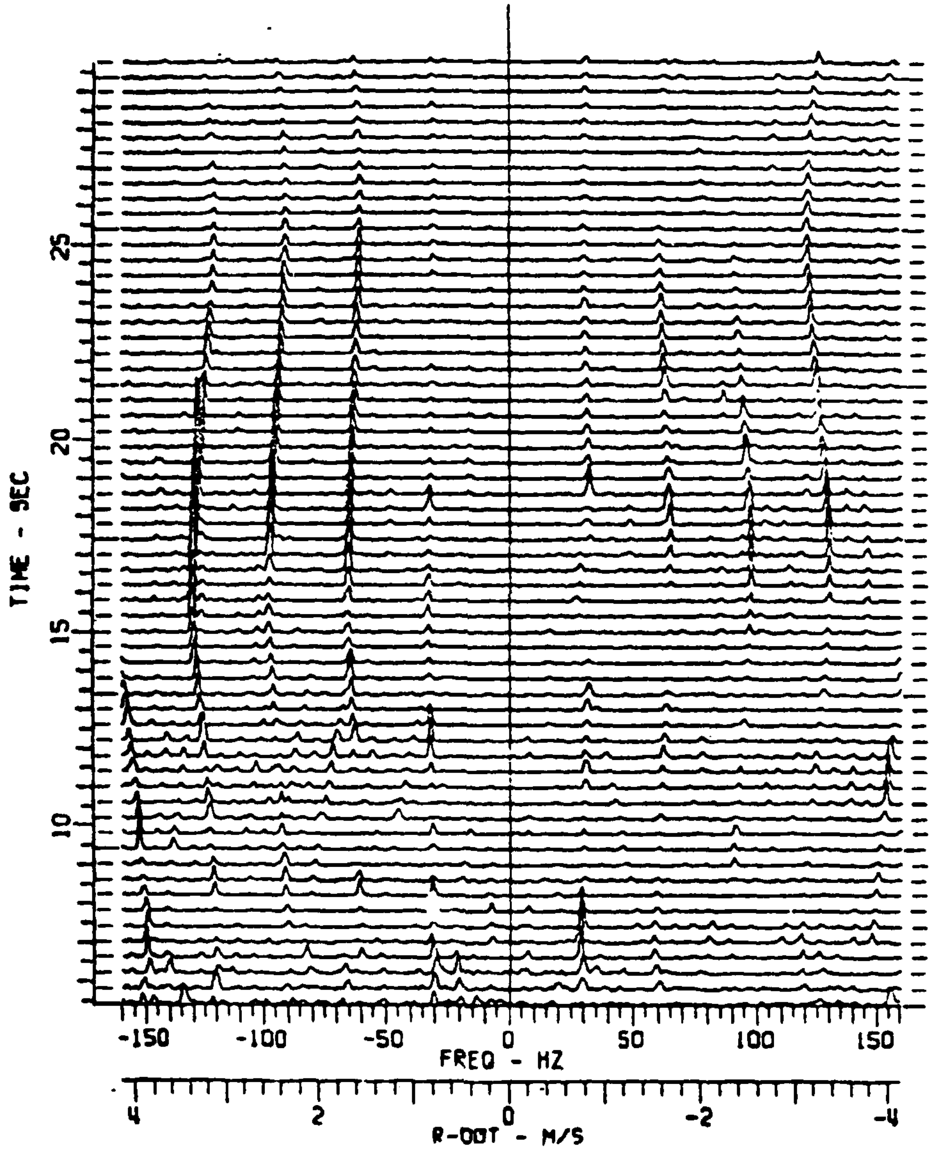

Figure 11(a). Doppler history plot with Fourier transform window equal to 32/5 cycle of spin and lag equal to 16/5 cycles of spin.

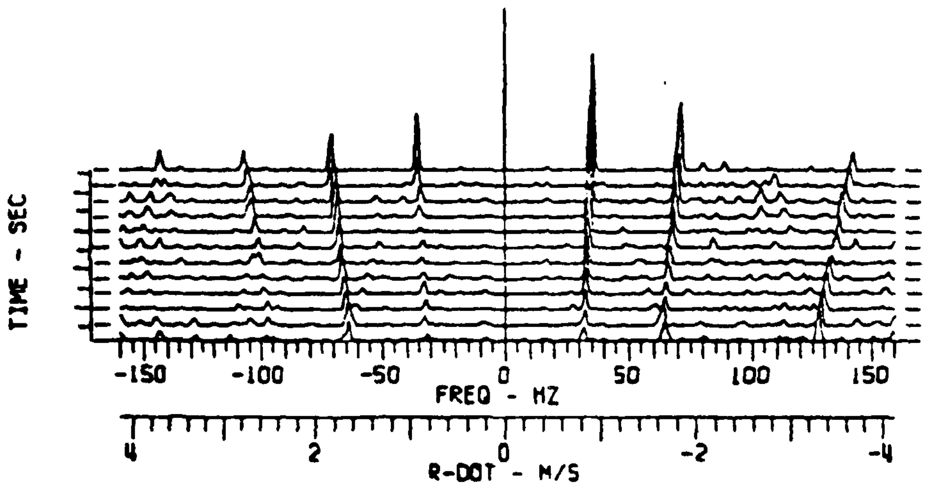

Figure 11(b). Doppler history plot with Fourier transform window equal to 32/5 cycle of spin and lag equal to 16/5 cycles of spin.

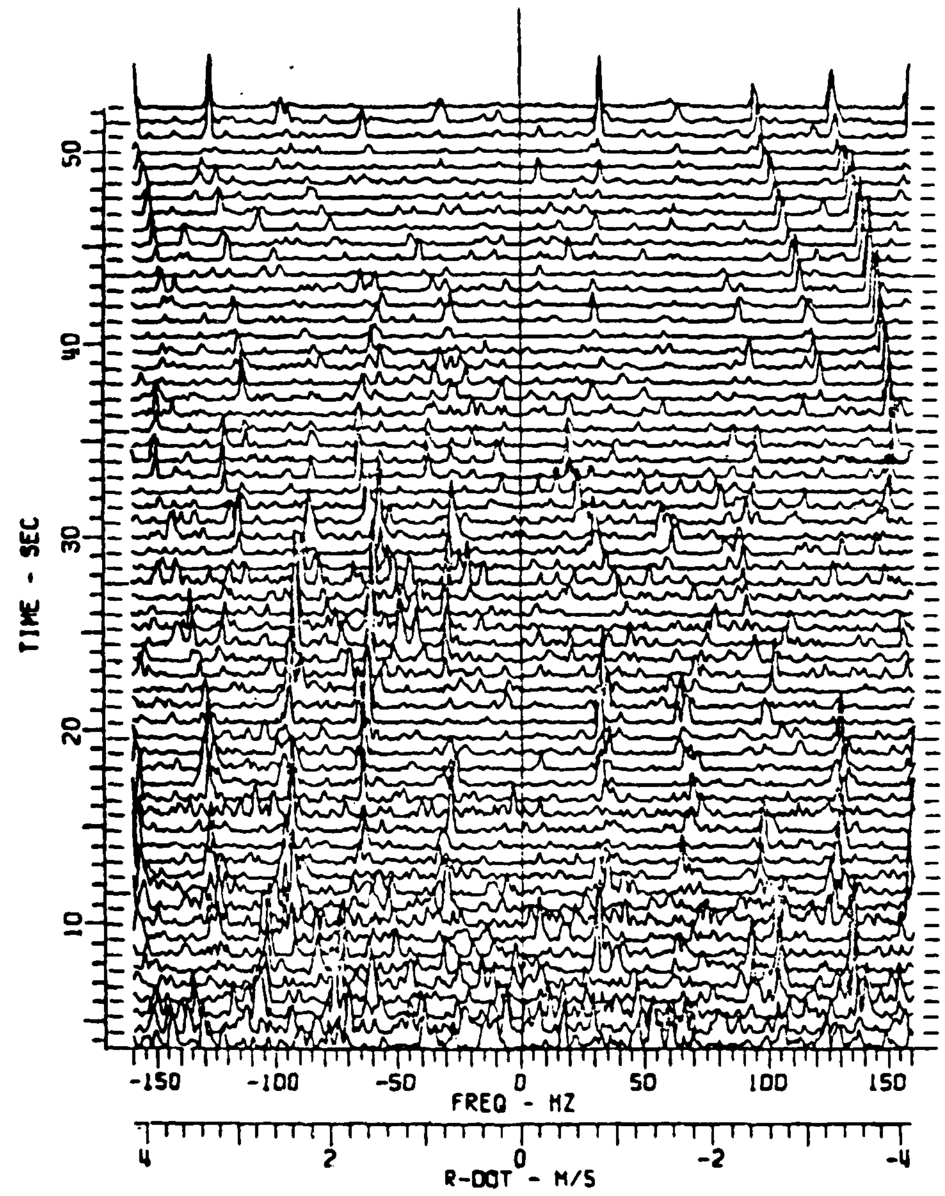

Figure 12(a). Doppler history plot representative of noise.

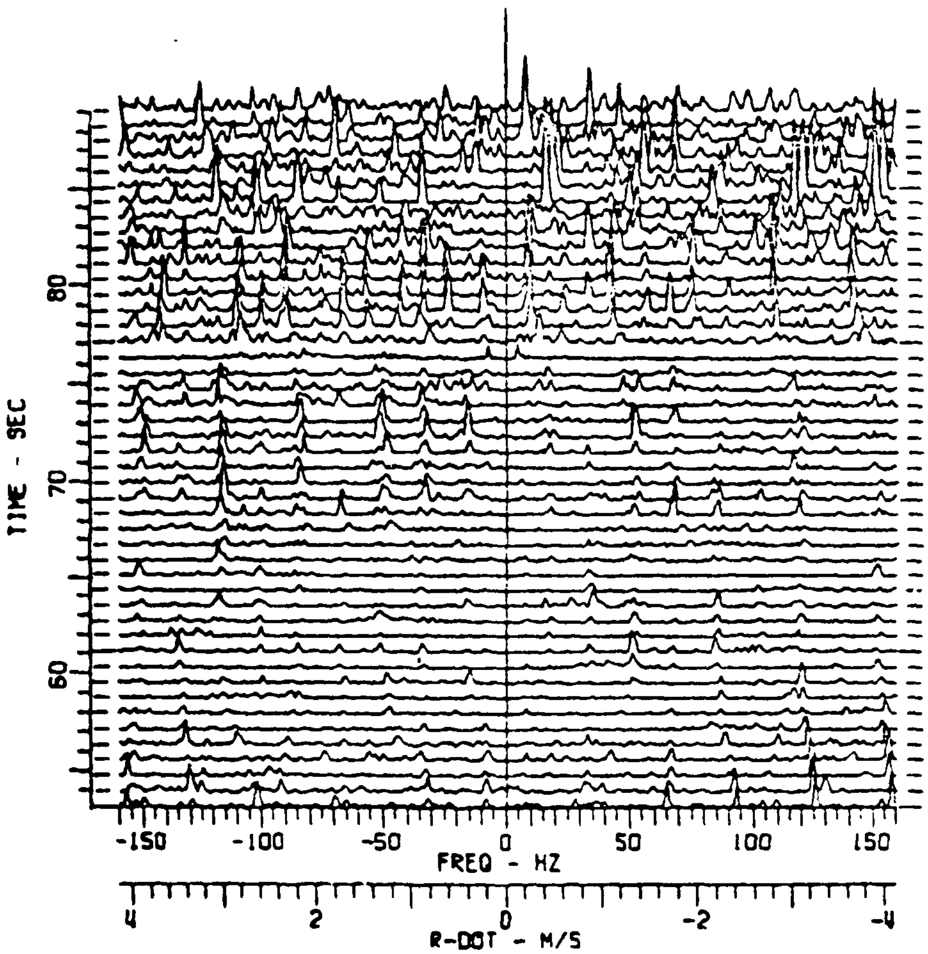

Figure 12(b). Doppler history plot representative of noise.

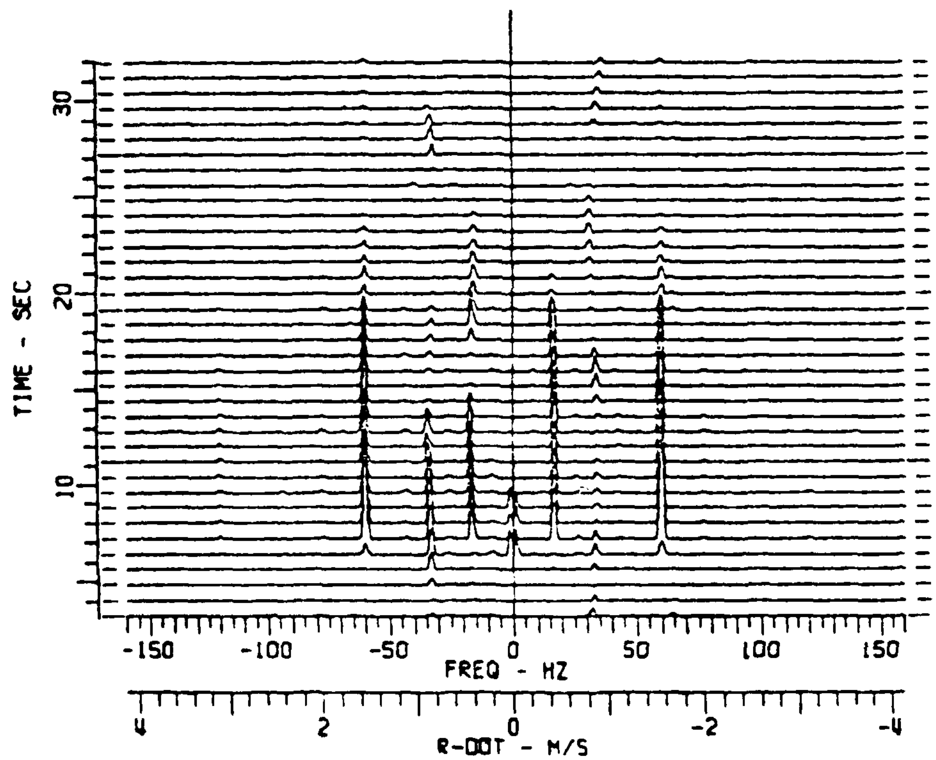

Figure 13. Doppler history plot illustrative of fading of spin traces.

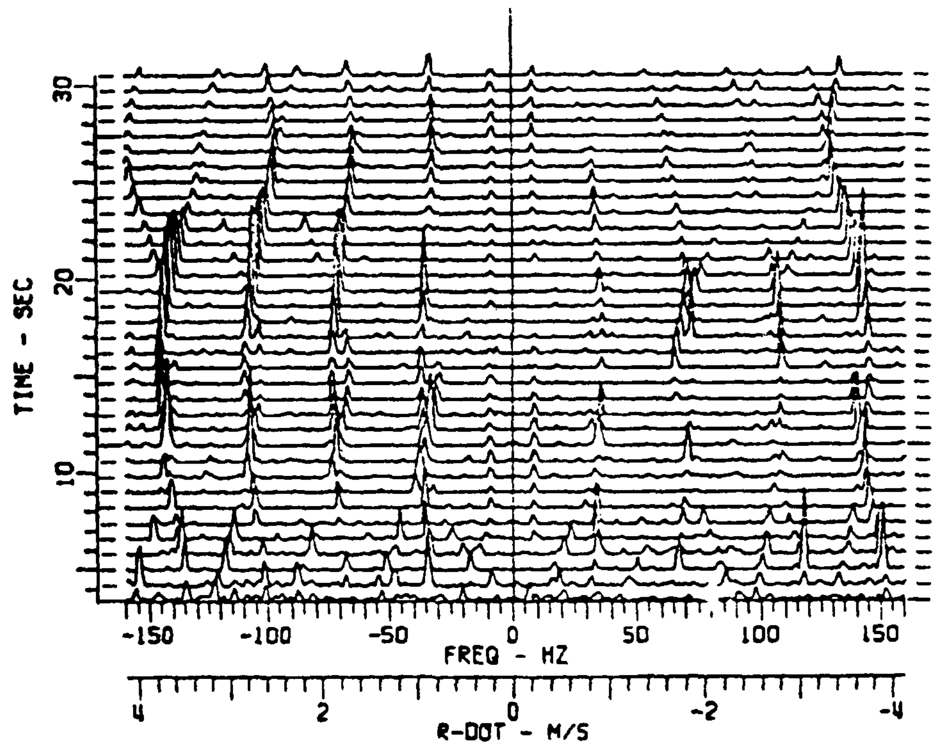

Figure 14. Doppler history plot illustrative of aliasing and crossover.

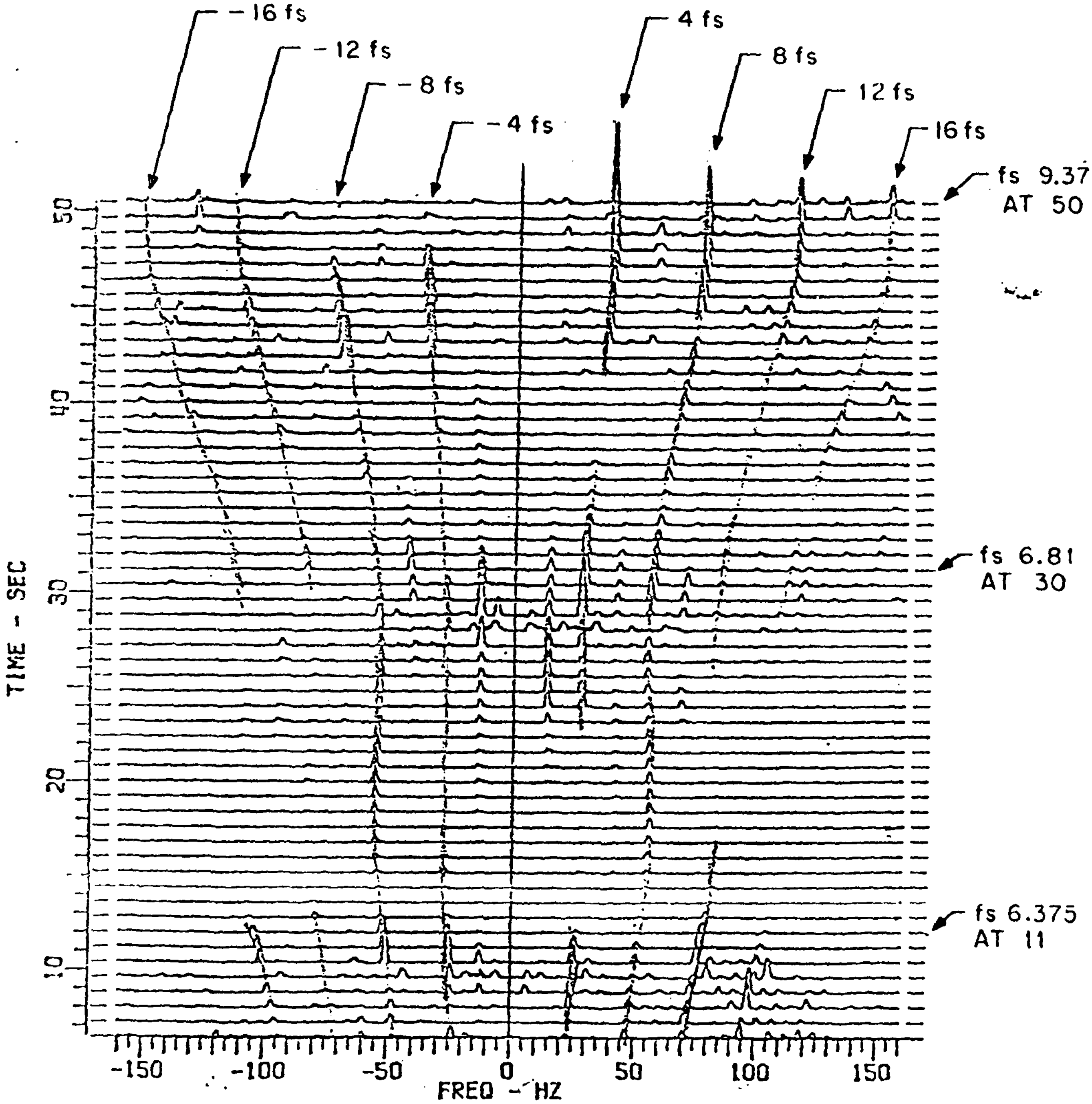

Figure 15. Manual analysis of a doppler history plot.

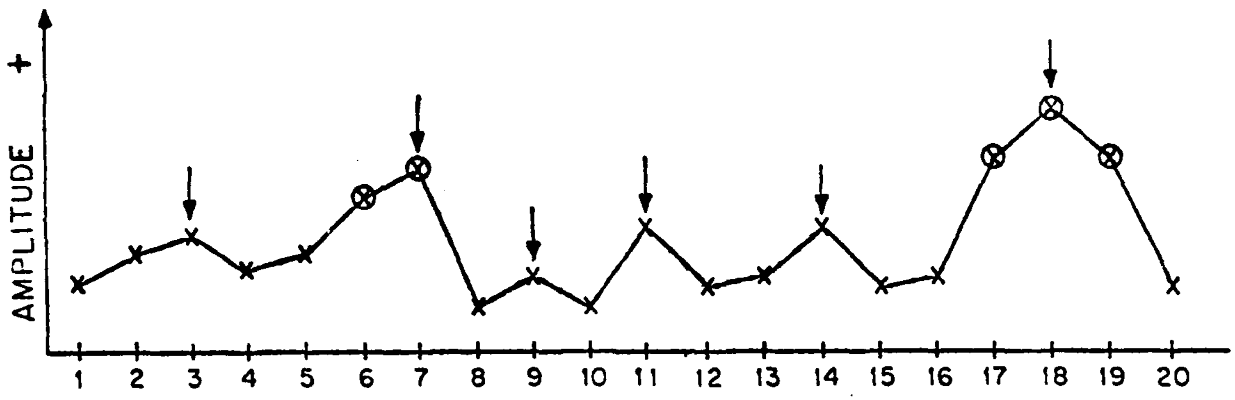

Figure 16. Selection of candidate spin returns.

GENERALIZED

KNOWLEDGE BASED SYSTEM (KBS)

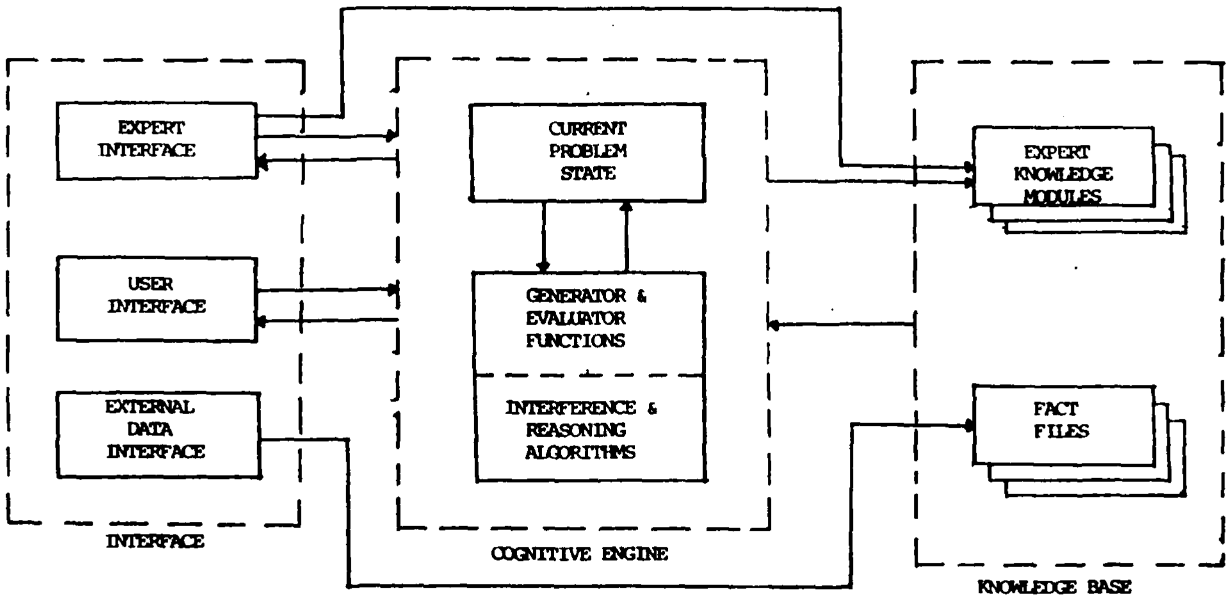

Figure 17. Knowledge based system.

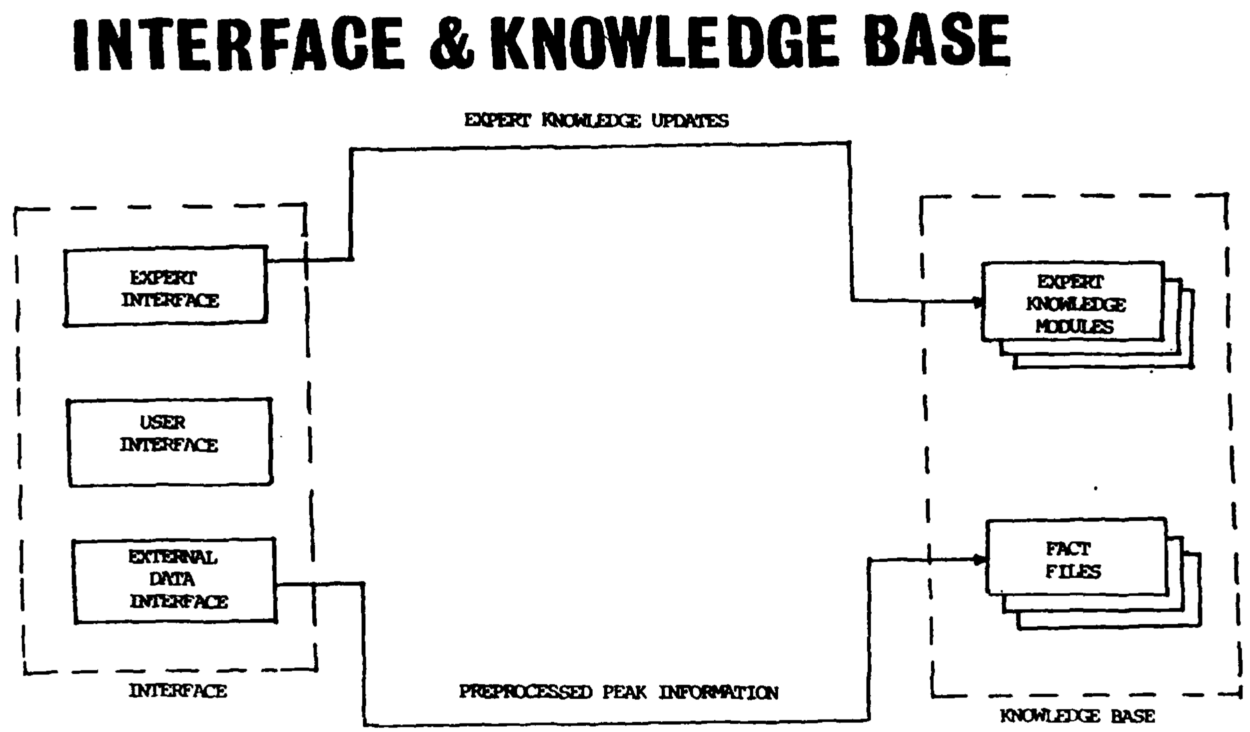

Figure 18. Interface and knowledge base.

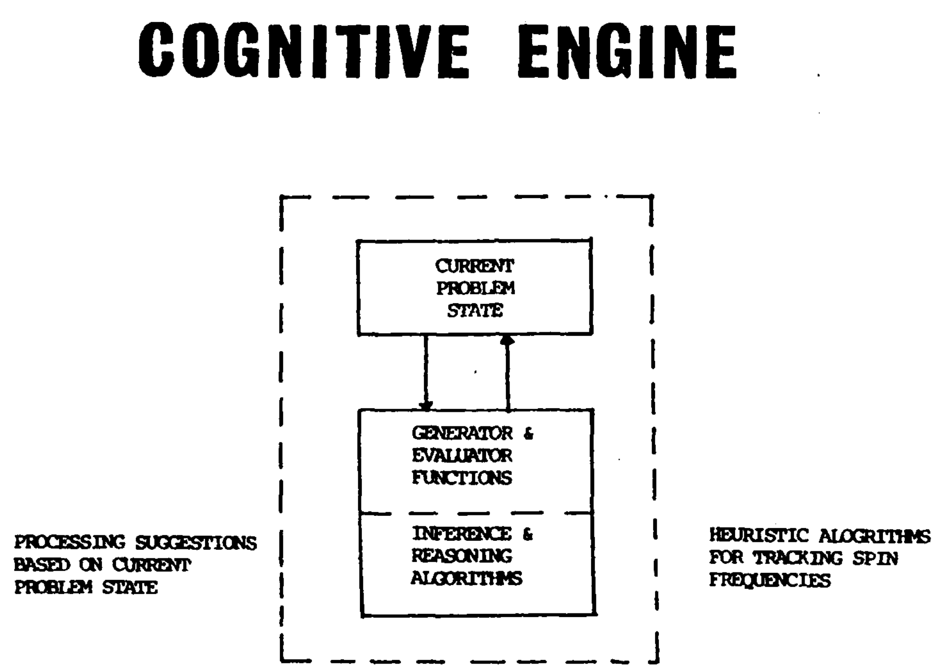

Figure 19. Cognitive engine.

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C
C  INITIALIZATION
C
      DIMENSION APBUF(1536),A(512),B(512),C(512)
      COMMON/FFTINI/INI,LOADED
      LOGICAL*1 FNAME(40),PNAME(40),BUF(100)
      LOGICAL LOADED,IFILTR
      LOGICAL HELP,STRING(10)
      DATA KBUF,NVAL/1,1/
      DATA INI,LOADED/0,.FALSE./
      NCOUNT=0
      OPEN(UNIT=4,NAME='DK2:[50,50]SPINSTAT.DAT',TYPE='OLD',
     1FORM='UNFORMATTED')
      REWIND(4)
      READ(4)NRUNS
      READ(4)NAVEPE
      READ(4)AVE4FS
      READ(4)N60HZ
      READ(4)SPFREQ
      READ(4)IFILTR
      READ(4)NCOUNT
      READ(4)NSEG
      READ(4)WINAVE
      READ(4)PCNT1
      READ(4)PCNT2
      READ(4)PCNT3
      READ(4)PCNT4
      TYPE 50
50    FORMAT(1X,'ENTER INPUT FILE NAME WITH DEVICE')
      READ (5,100)M,FNAME
100   FORMAT(Q,40A1)
      FNAME(M+1)=0
      TYPE 60,FNAME
```

```
60      FORMAT(1X,40A1)
        TYPE 51
51      FORMAT(1X,'ENTER OUTPUT FILE NAME WITH DEVICE')
        READ(5,100)M,PNAME
        PNAME(M+1)=0
        TYPE 60,PNAME
        TYPE*,'IF YOU NEED HELP TO ANSWER ANY'
        TYPE*,'QUESTION ,ENTER HELP'
600     TYPE 200
200     FORMAT(1X,'ENTER STARTING TIME BIAS')
        ACCEPT 20,(STRING(I),I=1,10)
20      FORMAT(10A1)
        CALL CONVER(STRING,HELP,TBIAS)
        IF(HELP)GO TO 500
        LAG=256
        LAG=LAG*2
610     TYPE*,'ENTER NUMBER OF PEAKS PER SPECTRUM YOU WANT TO SAVE'
        ACCEPT20,(STRING(I),I=1,10)
        CALL CONVER(STRING,HELP,ANUM)
        IF(HELP)GO TO 510
        NPEAKS=INT(ANUM)
620     TYPE *,'ENTER MINIMUM FREQUENCY FOR THE 4FS LINE'
        ACCEPT 20,(STRING(I),I=1,10)
        CALL CONVER(STRING,HELP,SPFREQ)
        IF(HELP)GO TO 520
        SPFREQ=SPFREQ-2
        TYPE*,'SPFREQ=',SPFREQ
        TYPE*,'DO YOU WANT TO FILTER OUT THE+/-60HERTZ'
        TYPE*,'LINE?,ENTER Y OR N OR H (H IS FOR HELP)'
630     ACCEPT 21,ICHAR
21      FORMAT(A1)
        IFILTR=.FALSE.
        IF(ICHAR.EQ.'Y')IFILTR=.TRUE.
        IF(ICHAR.NE.'N')GO TO 530
C
```

```
C        MAP 512 POINTS TO 320 HERTZ WINDOW
C
         DELTA=320.1729/512.
         DO 1400 I=1,512
         B(I)=-160.08645+(I-1)*DELTA
1400     C(I)=B(I)
C
C        OPEN WORK FILES
C
         OPEN(UNIT=1,NAME=FNAME,TYPE='OLD',READONLY,FORM='UNFORMATTED')
         OPEN(UNIT=2,NAME=PNAME,TYPE='NEW',FORM='UNFORMATTED')
         WRITE(2)NPEAKS
C
C    READ HEADER
C
         READ (1)IBUF
         IBUF=4*IBUF
         READ (1) (BUF(N),N=1,IBUF)
C        TYPE 300,IBUF,BUF
C300     FORMAT(1X,I5,2X,100A1)
C
C    READ DATA BUFFER
C
1000     READ(1,END=9001)IUFSZE
         IUFSZE=IUFSZE+NVAL-1
         READ(1)(APBUF(I),I=NVAL,IUFSZE)
C
C    FIND LOCATION OF FIRST AMP/PHASE AT STARTING TIME
C
C
         IST=1
         IF(KBUF.NE.1)GO TO 1005
         TBIAS=AMAX1(TBIAS,APBUF(1))
         WRITE(2)TBIAS
         IST=640.3448*(TBIAS-APBUF(1))+4.
```

```
      ICK=IST/2
      ICK1=IST-2*ICK
      IF(ICK1.EQ.0)IST=IST+1
C
C   FIND BUFFER WITH CORRECT START TIME
C
      NVAL=IST
1050  IF(IST.LT.1024) GO TO 1005
      IST=IST-1024
      NVAL=IST
      READ(1,END=9001)IUFSZE
      READ(1)(APBUF(I),I=1,IUFSZE)
      GO TO 1050
C
C   COMPUTE THE QUADRATURE COMPONENTS
C
1005  KSZE=IUFSZE-1
      DO 1010 K=NVAL,KSZE,2
      TEMP=APBUF(K)
      APBUF(K)=TEMP*COS(APBUF(K+1))
1010  APBUF(K+1)=TEMP*SIN(APBUF(K+1))
C
C   SHIFT APBUF() DATA FOR NEW READ IF NECESSARY
C
1100  IF((IUFSZE-IST).GE.512)GO TO 1200
      K=0
      DO 1150 M=IST,IUFSZE
      K=K+1
1150  APBUF(K)=APBUF(M)
      KBUF=KBUF+1
      NVAL=IUFSZE-IST+2
      GO TO 1000
C
C   LOAD FFT ARRAY
C
```

```
1200   K=-1
       IST511=IST+511
       DO 1250 M=IST,IST511,2
       K=K+2
       A(K)=APBUF(M)
1250   A(K+1)=APBUF(M+1)
C
C      CALL ARRAY PROCESSOR
C
       CALL FFT2(A,DUMMY,512,-2)
C
C     SHIFT TRANSFORMED DATA
C
       DO 1350 I=1,256
       TEMP=A(I)
       A(I)=A(I+256)
1350   A(I+256)=TEMP
       IST=IST+LAG
C
C      LOAD FREQUENCY ARRAY WITH VALUES
C
       IEOF=0
       DO 1500 I=1,512
1500   B(I)=C(I)
C
C      PICK UP PEAKS
C
       CALL PICK(A,B,M,SPFREQ,IFILTR)
C
C      ORDER FREQUENCY ACCORDING TO MAGNITUDE IN DESCENDING ORDER
C
       CALL SORTAG(A,M,B)
C
C      WRITE INTO DISK LARGEST PEAKS
C
```

```
      WRITE(2)((B(I),A(I)),I=1,NPEAKS)
      NCOUNT=NCOUNT+1
      GO TO 1100
500   TYPE*,'STARTING TIME BIAS IS THE TIME'
      TYPE*,'WHERE YOU WANT TO START PROCESSING,'
      TYPE*,'A 0 WILL DEFAULT TO THE FIRST TIME ON TAPE  '
      GO TO 600
510   TYPE*,'THIS IS THE NUMBER OF PEAKS/SPECTRUM'
      TYPE*,'THAT WILL BE SAVED FOR SUBSEQUENT '
      TYPE*,'TRACKING.USUALLY IT WILL BE THE NUMBER'
      TYPE*,'OF NON-WRAPPED SPIN LINES THAT CAN BE'
      TYPE*,'IDENTIFIED IN THE DOPPLER PLOT.'
      TYPE*,'REMEMBER EACH POSITIVE AND NEGATIVE'
      TYPE*,'LINE,COUNT AS 1.'
      TYPE*,'IN THE PRESENCE OF LARGE'
      TYPE*,'NOISE PEAKS RELATIVE TO THE SPIN LINE'
      TYPE*,'PEAKS,YOU MAY GET BETTER RESULTS BY'
      TYPE*,'INCREASING THE NUMBER YOU ENTER BY'
      TYPE*,'2 OR 3.'
      TYPE*,'FOR THE LAST',NRUNS,'RUNS,THE'
      TYPE*,'AVERAGE NUMBER OF PEAKS SAVED WAS'
      TYPE*,NAVEPE
      GO TO 610
520   TYPE*,'THIS IS THE MINIMUM FREQUENCY VALUE THAT'
      TYPE*,'THE +/- 4FS LINE WILL TAKE THROUGHOUT'
      TYPE*,'THE DOPPLER PLOT,AN ANSWER TO THE'
      TYPE*,'NEAREST HERTZ IS SUFFICIENT.IF YOU'
      TYPE*,'ARE NOT ABLE TO IDENTIFY THE 4FS LINE'
      TYPE*,'ENTER 20 AS THE MINIMUM FREQUENCY.'
      TYPE*,'THE MINIMUM FREQUENCY FOR THE 4FS LINE'
      TYPE*,'IS BETWEEN 20 AND 60 HERTZ,THE AVERAGE'
      TYPE*,'MINIMUM FROM THE LAST',NRUNS,'RUNS,IS',AVE4FS
      GO TO 620
530   TYPE*,'THERE MAY BE A VERY STRONG LINE AT'
      TYPE*,'+/-60 HERTZ THAT DOES NOT SEEM TO BE'
```

```
      TYPE*,'A SPIN LINE.IF YOU WISH TO HAVE THIS'
      TYPE*,'REMOVED BEFORE TRACKING ,ANSWER Y'
      GO TO 630
9001  REWIND (4)
      WRITE(4)NRUNS
      WRITE(4)NAVEPE
      WRITE(4)AVE4FS
      WRITE(4)N60HZ
      WRITE(4)SPFREQ
      WRITE(4)IFILTR
      WRITE(4)NCOUNT
      WRITE(4)NSEG
      WRITE(4)WINAVE
      WRITE(4)PCNT1
      WRITE(4)PCNT2
      WRITE(4)PCNT3
      WRITE(4)PCNT4
      STOP
      END
>
```

```
      SUBROUTINE SORTAG(VIN,NSIZE,AIN)
      DIMENSION AIN(1),VIN(1)
      ITOP=NSIZE-1
      DO 100 I=1,ITOP
      JBOT=I+1
      DO 90 J=JBOT,NSIZE
      IF(VIN(J).LT.VIN(I))GO TO 90
      VSAVE=VIN(J)
      ASAVE=AIN(J)
      VIN(J)=VIN(I)
      AIN(J)=AIN(I)
      VIN(I)=VSAVE
      AIN(I)=ASAVE
90    CONTINUE
100   CONTINUE
      RETURN
      END
>
```

```
      SUBROUTINE PICK(A,B,M,FREQ,IFILTR)
      DIMENSION A(1),B(1)
      LOGICAL IFILTR
      IFLAG=1
      M=0
      TEST=A(1)
      DO 100 I=1,511
      IF(TEST.GT.A(I+1))GO TO 20
      IFLAG=1
      GO TO 100
20    IF(IFLAG.EQ.0)GO TO 100
      IFLAG=0
      IF(ABS(B(I)).LT.FREQ)GO TO 100
      IF(IFILTR.AND.ABS(B(I)).EQ.60.)GO TO 100
      M=M+1
      A(M)=TEST
      B(M)=B(I)
100   TEST=A(I+1)
      RETURN
      END
>
```

```
      SUBROUTINE FFT2(DATA,DUMMY,NNFFT,KEY)
      LOGICAL LOADED
      COMMON/FFTINI/INI,LOADED
      IF(KEY.NE.-2)STOP 'FFT2 KEY'
      IF(NNFFT.LT.4)STOP 'FFT2 NFFT'
      NN=ALOG(FLOAT(NNFFT))*1.442695+.01
      NFFT=2**NN
      IF(NFFT.GT.1024)STOP 'FFT2 1024NFFT'
      IF(NFFT.EQ.INI)GO TO 100
      IF(LOADED)GO TO 80
      CALL APAVAL(I)
      IF(I.NE.0)STOP 'NO AP-400'
      CALL KSETIW(0)
      CALL KRESET
      CLOSE (UNIT=3)
      CALL KLOAD(3,'DB:[50,50]SUBFFT21.APO')
      LOADED=.TRUE.
      CALL KALDB(2*NFFT,3)
      INI=NFFT
      GO TO 100
80    CALL KRDBS
      CALL KALDB(2*NFFT,3)
      INI=NFFT
100   CALL KHFAB(DATA,3,NFFT)
      CALL KZPDB(3,NFFT+1,NFFT)
      CALL KFFTC1(2*NFFT,3,3)
      CALL KBRVC(3,3)
      CALL KCMGS(3,3)
      CALL KABHF(DATA,3,NFFT)
      CALL KWAIT
      RETURN
      END
>
```

```
      SUBROUTINE CONVER(A,HELP,B)
      LOGICAL A(1)
      LOGICAL HELP,NEG
C
C     CHECK FOR INVALID DATA
C
      NEG=.FALSE.
      HELP=.FALSE.
      DO 10 I=1,10
      IF(A(I).NE.' '.AND.(A(I).LT.'.'.OR.A(I).GT.
     1'9'))HELP=.TRUE.
      IF(A(I).EQ.'/')HELP=.TRUE.
10    IF(A(I).EQ.'+'.OR.A(I).EQ.'-')HELP=.FALSE.
      IF(HELP)RETURN
C
C     SCRUNCH LEADING BLANKS
C
20    IF(A(I).NE.' ')GO TO 40
      DO 30 I=1,9
30    A(I)=A(I+1)
      A(10)=' '
      GO TO 20
C
C     CALCULATE NUMBER
C
40    J=1
      IF(A(1).EQ.'+')J=2
      IF(A(1).NE.'-')GO TO 45
      J=2
      NEG=.TRUE.
45    IFLAG=0
      B=0
      C=0
      DO 100 I=J,10
```

```
      IF(A(I).EQ.' ')GO TO 110
      IF(A(I).NE.'.')GO TO 50
      IFLAG=1
      GO TO 100
50    IF(IFLAG.GT.0)GO TO 60
      B=B*10+(A(I)-'0')
      GO TO 100
60    C1=A(I)-'0'
      C=C+C1/10.**IFLAG
      IFLAG=IFLAG+1
100   CONTINUE
110   B=B+C
      IF(NEG)B=-B
      RETURN
      END
>
```

```
      PROGRAM MAIN
C*****************************************************
C*                                                   *
C*    THIS PROGRAM IS GOING TO READ A FILE OF PEAKS  *
C*                                                   *
C*    AND IDENTIFIY THE SPIN FREQUENCY FOR EACH TIME *
C*                                                   *
C*    SPECTRUM.                                      *
C*                                                   *
C*****************************************************
      DIMENSION PEAKY(40),AMPEAK(40),CAND(20),B(20),TIMES(120),SPFR(120,
2)
      1,TGOOD(120),SGOOD(120)
      LOGICAL*1 PNAME(40)
      COMMON /STAT/NRUNS,NAVEPE,AVE4FS,N60HZ,SPFREK,IFILTR,NUMLIN
      1,NSEG,WINAVE,PCNT1,PCNT2,PCNT3,PCNT4
      COMMON /STAT1/NSEG1,WIN1,IC1(2),IC2(2),IC3(2),IC4(2),
      1PC1,PC2,PC3,PC4
      COMMON /TIEMPO/TIMELY(10,2)
      LOGICAL HELP,STRING(10),IFILTR,INIT
      TYPE*,'ENTER INPUT FILE NAME WITH DEVICE'
      READ(5,12)M,PNAME
12    FORMAT(Q,40A1)
      PNAME(M+1)=0
      INIT=.FALSE.
C
C     OPEN WORKING FILES
C
      OPEN(UNIT=1,NAME=PNAME,TYPE='OLD',FORM='UNFORMATTED')
      OPEN(UNIT=2,NAME='PEAKFRE.DAT',TYPE='SCRATCH',FORM='UNFORMATTED')
      OPEN(UNIT=3,NAME='DK2:[50,50]SPINSTAT.DAT',TYPE='OLD',
      1FORM='UNFORMATTED')
      ITIME=0
      ICO=1
```

```
      CALL INICLO(INIT)
      INIT=.TRUE.
      TYPE*,'IF YOU NEED HELP TO ANSWER'
      TYPE*,'ANY OF THE QUESTIONS,ENTER HELP'
C
C     CALCULATE TIME FOR EACH LINE AND FINAL TIME
C
      READ(1)NPEAKS
      READ(1)STIME
      STIME=STIME+128.5/320.1729
      DO 950 KL=1,120
950   TIMES(KL)=STIME+(KL-1)*.799568
      FTIME=TIMES(NUMLIN)
C
C     PROCESS ONE SPECIFIC TIME INTERVAL
C
900   ITIME=ITIME+1
800   TYPE *,'ENTER TRACK WINDOW LENGTH'
      ACCEPT 20,(STRING(I),I=1,10)
20    FORMAT(10A1)
      CALL CONVER(STRING,HELP,WINLEN)
      IF(HELP)GO TO 700
810   TYPE*,'ENTER MAXIMUM MULTIPLE TO LOOK FOR'
      ACCEPT 20,(STRING(I),I=1,10)
      CALL CONVER(STRING,HELP,A)
      IF(HELP)GO TO 710
      MAXMUL=INT(A)
      REWIND 1
      REWIND 2
      READ(1) NPEAKS
      READ(1) STIME
      DO 2090 I=1,2
      IC1(I)=0
      IC2(I)=0
      IC3(I)=0
```

```
2090    IC4(I)=0
        TYPE*,'START TIME IS=',STIME
        TYPE*,'FINAL TIME IS=',FTIME
C
C       ACCEPT TIME INTERVAL TO BE PROCESSED
C
1000    TYPE*,'ENTER TIME YOU WANT TO START AT'
        ACCEPT 20,(STRING(I),I=1,10)
        CALL CONVER(STRING,HELP,TIME1)
        IF(HELP)GO TO 720
        IF(TIME1.LT.(STIME-1).OR.TIME1.GT.(FTIME+1))GO TO 1000
1100    TYPE*,'ENTER TIME YOU WANT TO STOP AT'
        ACCEPT 20,(STRING(I),I=1,10)
        CALL CONVER(STRING,HELP,TIME2)
        IF(HELP)GO TO 730
        IF(TIME2.LT.(STIME-1).OR.TIME2.GT.(FTIME+1))GO TO 1100
        CALL TIMEIN(IFL,TIME1,TIME2,ITIME)
        IF(IFL.EQ.1)GO TO 1000
        GO TO 1200
C
C       REVERSE DATA FOR BACKWARDS PROCESSING
C
200     TYPE*,'BACKWARDS PROCESSING STARTS'
        LUN=2
        IFLAGY=2
        CALL REVERS(NLINES,NPEAKS)
        REWIND 2
        GO TO 35
C
C       PROCESS FORWARD AND SKIP LINES IF FIRST TIME NOT STIME
C
1200    TYPE*,'FORWARD PROCESSING STARTS'
        LUN=1
        IFLAGY=1
        IGO=0
```

```
      NLINES=0
      DO 450 L=1,120
      IF(TIMES(L).GE.TIME1)GO TO 350
450   IGO=IGO+1
350   DO 550 L=IGO+1,120
      IF(TIMES(L).GT.TIME2)GO TO 650
550   NLINES=NLINES+1
650   IF(IGO.EQ.0)GO TO 35
      DO 40 L=1,IGO
40    READ(1)((PEAKY(J),AMPEAK(J)),J=1,NPEAKS)
35    ICOUNT=1
      ITIME=IGO+NLINES+1
C
C     READ IN ONE TIME SPECTRUM AT A TIME AND PROCESS IT
C
100   READ(LUN)((PEAKY(J),AMPEAK(J)),J=1,NPEAKS)
      ITIME=ITIME-1
      T1=TIMES(ITIME)
      IF(IFLAGY.EQ.2)GO TO 101
      ITIME=IGO+ICOUNT
      T1=TIMES(ITIME)
      WRITE(2)((PEAKY(J),AMPEAK(J)),J=1,NPEAKS)
101   IF (ICOUNT.NE.1)GO TO 10
C
C  IDENTIFY ONE OF THE SPIN LINES AND PROMPT USER FOR CORRECTNESS
C
      CALL MENU(PEAKY,AMPEAK,SPFREQ,T1,IC1,IFLAGY)
C
C     TRACK SPIN LINES FOR PARTICULAR TIME SPECTRUM
C
10    CALL SPTRK1(WINLEN,MAXMUL,NPEAKS,SPFREQ,PEAKY,AMPEAK,T1,IFLAGY)
      SPFR(ICO,IFLAGY)=SPFREQ
      IF(ICOUNT.EQ.1)GO TO 50
      IF(ICOUNT.NE.2)GO TO 60
C
```

```
C
C       CALCULATE THE SECOND SPIN FREQUENCY
C
        SPFREQ=2*SPFR(ICO,IFLAGY)-SPFR(ICO-1,IFLAGY)
        GO TO 50
C
C
C       MAKE A 3 POINT LEAST SQUARES PREDICTION OF NEXT SPIN FREQ.
C
30      CALL SPFIT(SPFR,SPFREQ,ICO,IFLAGY)
50      ICOUNT=ICOUNT+1
        ICO=ICO+1
        IF(ICOUNT.LE.NLINES)GO TO 100
        ICO=ICO-NLINES
        IF(IFLAGY.EQ.1)GO TO 200
C
C
C       PRINT OUT SPIN FREQUENCIES FOUND,WITH ASSOCIATED TIME
C
        TYPE 70
70      FORMAT(5X,'TIME',10X,'FORWARD PROCESS',10X,'BACKWARD PROCESS')
        CALL REVDAT(SPFR,ICO,NLINES)
        DO 11 I=ICO,ICO+NLINES-1
        IGO=IGO+1
11      TYPE 1300,TIMES(IGO),SPFR(I,1),SPFR(I,2)
1300    FORMAT(F10.5,12X,F10.5,14X,F10.5)
        TYPE*,'DO YOU AGREE WITH THE DATA?,'
        TYPE*,'EITHER FORWARD OR BACKWARDS'
        TYPE*,'ENTER Y OR N.'
2020    ACCEPT 1,ANSW
        IF(ANSW.EQ.'Y')GO TO 2000
        IF(ANSW.EQ.'N')GO TO 2010
        TYPE*,'THERE IS NO HELP TO THIS QUESTION'
        TYPE*,'ENTER Y OR N PLEASE'
        GO TO 2020
2000    TYPE*,'DO YOU WANT TO SAVE THE FORWARD'
        TYPE*,'OR THE BACKWARD DATA? ENTER'
        TYPE*,'1 FOR THE FORWARD DATA'
```

```
      TYPE*,'2 FOR THE BACKWARD DATA'
2050  ACCEPT*,NFB
      IF(NFB.EQ.1.OR.NFB.EQ.2)GO TO 2030
      TYPE*,'PLEASE ENTER EITHER 1 OR 2'
      GO TO 2050
2030  DO 2040 I=ICO,ICO+NLINES-1
      IGO=IGO+1
      TGOOD(I)=TIMES(IGO)
2040  SGOOD(I)=SPFR(I,NFB)
      ICO=ICO+NLINES
      CALL COMPUT(NLINES,NFB,WINLEN)
95    TYPE*,'DO YOU WANT TO PROCESS MORE'
      TYPE*,'SEGMENTS OF DATA? ENTER Y OR N'
      ACCEPT 1,ANSW
1     FORMAT(A1)
      IF(ANSW.EQ.'Y')GO TO 900
      TYPE*,'DO YOU AGREE WITH THIS RUN?'
      TYPE*,'ENTER Y OR N'
      ACCEPT 1,ANSW
      IF(ANSW.NE.'Y')GO TO 2070
      CALL COMFIN(NPEAKS)
      TYPE*,'DO YOU WANT TO SEE THE STATISTICS'
      TYPE*,'OF THIS RUN? ENTER Y OR N.'
      ACCEPT1,ANSW
      IF(ANSW.EQ.'Y')CALL PRINTS(NPEAKS)
      CALL INICLO(INIT)
      STOP
2070  TYPE*,'I CAN GIVE YOU SOME SUGGESTIONS THAT'
      TYPE*,'WILL PROBABLY IMPROVE YOUR OUTPUT'
      TYPE*,'ENTER Y OR N.'
      ACCEPT 1,ANSW
      IF(ANSW.NE.'N')CALL SUG2
      TYPE*,'STATISTICS WILL NOT BE SAVED FOR'
      TYPE*,'THIS RUN.'
      STOP
```

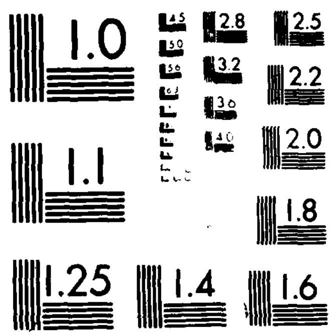
```
2010    TYPE*,'DO YOU WANT ANY SUGGESTIONS THAT WILL'
        TYPE*,'PROBABLY IMPROVE YOUR OUTPUT?'
        TYPE*,'ENTER Y OR N'
        ACCEPT 1,ANSW
        IF(ANSW.NE.'N')CALL SUG1(NLINES,MAXMUL)
        TYPE*,'DO YOU WANT TO PROCESS THIS SEGMENT AGAIN?'
        TYPE*,'ENTER Y OR N'
        ACCEPT 1,ANSW
        IF(ANSW.NE.'Y')GO TO 95
        GO TO 800
700     TYPE*,'THIS IS THE TOLERANCE TO '
        TYPE*,'FIND THE PEAKS CORRESPONDING'
        TYPE*,'TO THE SPIN LINES'
        TYPE*,'IF THE WINDOW LENGTH IS TOO BIG,'
        TYPE*,'YOU WILL PROBABLY PICK UP NOISY PEAKS'
        TYPE*,'IF IT IS TOO SMALL THEN YOU WILL MISS'
        TYPE*,'SOME OF THE CORRECT PEAKS AND WILL'
        TYPE*,'BE ASKED TO INPUT THE CORRECT FREQUENCY'
        TYPE*,'THE AVERAGE WINDOW LENGTH FOR THE'
        TYPE*,'PREVIOUS',NSEG,'SEGMENTS PROCESSED IS',WINAVE
        GO TO 800
710     TYPE*,'THIS IS THE MAX MULTIPLE THAT'
        TYPE*,'THE TRACKER WILL SEARCH FOR.'
        TYPE*,'THE MULTIPLE TO SELECT IS THE MAX SPIN'
        TYPE*,'LINE THAT DO NOT WRAP AROUND.'
        TYPE*,'SELECT A SMALLER MULTIPLE IF'
        TYPE*,'THE HIGHER MULTIPLES ARE'
        TYPE*,'OBSCURED BY NOISE'
        GO TO 810
720     TYPE*,'THIS IS THE TIME WHERE'
        TYPE*,'PROCESSING  BEGIN,IT CAN NOT'
        TYPE*,'BE OUT OF THE RANGE FOR THE DATA.'
        GO TO 1000
730     TYPE*,'THIS IS THE TIME WHERE'
        TYPE*,'PROCESSING OF THIS SEGMENT WILL'
```

```
TYPE*,'STOP,IT CAN NOT BE OUT OF THE'
TYPE*,'RANGE FOR THE DATA,AND CAN NOT BE'
TYPE*,'SMALLER THAN THE START TIME.'
GO TO 1100
END
```

```
      SUBROUTINE INICLO(INIT)
      COMMON /STAT/NRUNS,NAVEPE,AVE4FS,N60HZ,SPFREK,IFILTR,NUMLIN,
     1NSEG,WINAVE,PCNT1,PCNT2,PCNT3,PCNT4
      COMMON /STAT1/NSEG1,WIN1,IC1(2),IC2(2),IC3(2),IC4(2),
     1PC1,PC2,PC3,PC4
      LOGICAL IFILTR,INIT
      IF(INIT)GO TO 10
      REWIND(3)
C     NRUNS IS THE NUMBER OF TIMES THE PROGRAM HAVE RUN SUCCESSFULLY
      READ(3)NRUNS
C     NAVEPE IS THE AVERAGE NUMBER OF PEAKS SAVED IN PEAKS1 PROGRAM
      READ(3)NAVEPE
C     AVE4FS IS THE AVERAGE FREQUENCY OF THE 4FS SPIN LINE
      READ(3)AVE4FS
C     N60HZ IS THE NUMBER OF TIMES THE 60 HERTZ LINE HAS BEEN REMOVED
      READ(3)N60HZ
C     SPFREK IS THE 4FS FREQUENCY FOR THIS RUN
      READ(3)SPFREK
C     IFILTR IS TRUE IF THE 60 HZ LINE IS REMOVED IN THIS RUN
      READ(3)IFILTR
C     NUMLIN IS THE NUMBER OF LINES IN THE CURRENT DATA
      READ(3)NUMLIN
C     NSEG IS THE NUMBER OF SEGMENTS RUN UP TO THIS CURRENT RUN
      READ(3)NSEG
C     WINAVE IS THE AVERAGE WINDOW TOLERANCE OF ALL THE RUNS
      READ(3)WINAVE
C     PCNT1 IS THE NUMBER OF TIMES THE LARGEST PEAK CORRESPONDED
C     TO A SPIN LINE,ACCORDING TO THE NUMBER OF SEGMENTS
      READ(3)PCNT1
C     PCNT2 IS THE PERCENTAGE THAT THE USER WAS REQUESTED TO
C     INPUT THE CORRECT SPIN FREQUENCY
      READ(3)PCNT2
C     PCNT3 IS THE PERCENTAGE THAT THE PROGRAM CAME OUT
C     WITH THE RIGHT FREQUENCY
```

AD-A171 828 SPIN FREQUENCY DETECTION IN THE SPECTRAL DOMAIN(U) 2/2
WHITE SANDS MISSILL RANGE NM INSTRUMENTATION
DIRECTORATE D S JIMAREZ MAR 86 STEWS-ID-86-1

UNCLASSIFIED F/G 17/9 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

```
      READ(3)PCNT3
C     PCNT4 IS THE PERCENTAGE THAT THE USER WAS REQUESTED TO
C     SELECT OUT OF SEVERAL FREQUENCIES THE RIGHT ONE
      READ(3)PCNT4
      WIN1=0
      NSEG1=0
      PC1=0
      PC2=0
      PC3=0
      PC4=0
      RETURN
10    REWIND 3
      WRITE(3)NRUNS
      WRITE(3)NAVEPE
      WRITE(3)AVE4FS
      WRITE(3)N60HZ
      WRITE(3)SPFREK
      WRITE(3)IFILTR
      WRITE(3)NUMLIN
      WRITE(3)NSEG
      WRITE(3)WINAVE
      WRITE(3)PCNT1
      WRITE(3)PCNT2
      WRITE(3)PCNT3
      WRITE(3)PCNT4
      RETURN
      END
>
```

```
      SUBROUTINE TIMEIN(IFL,TIME1,TIME2,ITIME)
C**********************************************************
C*                                                        *
C*    THIS ROUTINE WILL CHECK IF THE TIME INTERVAL        *
C*                                                        *
C*    IS NOT OVERLAPING WITH A PREVIOUS ONE               *
C*                                                        *
C**********************************************************
      COMMON /TIEMPO/TIMELY(10,2)
      IFL=0
      TIMELY(ITIME,1)=TIME1
      TIMELY(ITIME,2)=TIME2
      IF(ITIME.LE.1)RETURN
      DO 10 I=1,ITIME-1
      IF(TIMELY(ITIME,1).GT.TIMELY(I,1).AND.
     1TIMELY(ITIME,1).LT.TIMELY(I,2))GO TO 20
      IF(TIMELY(ITIME,2).GT.TIMELY(I,1).AND.
     1TIMELY(ITIME,2).LT.TIMELY(I,2))GO TO 20
10    CONTINUE
      RETURN
20    TYPE*,'TIME OVERLAP,TRY AGAIN'
      IFL=1
      RETURN
      END
>
```

```
      SUBROUTINE REVERS(NLINES,NPEAKS)
C**********************************************************
C*                                                        *
C*    THIS ROUTINE WILL REVERSE A FILE WITH NLINES        *
C*                                                        *
C**********************************************************
      DIMENSION PEAKS(60,40),AMPEAK(60,40)
C
C     READ AND THEN STORE IN REVERSE ORDER THE DATA
C
      REWIND 2
      DO 10 I=1,NLINES
10    READ(2)((PEAKS(I,J),AMPEAK(I,J)),J=1,NPEAKS)
      REWIND 2
      DO 30 K=NLINES,1,-1
30    WRITE(2)((PEAKS(K,J),AMPEAK(K,J)),J=1,NPEAKS)
      RETURN
      END
>
```

```
      SUBROUTINE MENU (X,Y,FREQ,T1,IC1,IFLAGY)
C*****************************************************
C*                                                   *
C*    THIS ROUTINE OFFERS THE USER THE OPPORTUNITY TO *
C*                                                   *
C*    CORRECT THE CALCULATED SPIN FREQUENCY,ACCORDING *
C*                                                   *
C*    TO HIS MANUAL CALCULATIONS.                    *
C*                                                   *
C*****************************************************
      DIMENSION IC1(2),X(1),Y(1)
      LOGICAL HELP,STRING(10)
      TYPE*,'THE SPIN FREQUENCY FOR THE LARGEST PEAK '
      TYPE*,'AT',T1,'SECONDS,IS',X(1)
      TYPE*,'DOES THIS FREQUENCY CORRESPONDS TO ANY OF '
      TYPE*,'THE SPIN  LINES? Y OR N OR H (FOR HELP)'
200   ACCEPT 10,ANSW
10    FORMAT(A1)
      IF (ANSW.EQ.'Y')GO TO 30
      IF (ANSW.NE.'N')GO TO 100
      TYPE*,'ENTER THE RIGHT FREQUENCY FOR THIS LINE'
210   ACCEPT 20,(STRING(I),I=1,10)
20    FORMAT(10A1)
      CALL CONVER(STRING,HELP,FREQ)
      IF(HELP)GO TO 110
      RETURN
100   TYPE*,'THE LARGEST PEAK IN THIS LINE WAS'
      TYPE*,'CHOSEN,IF THIS PEAK CORRESPONDS TO '
      TYPE*,'ANY OF THE SPIN LINES ENTER Y,ELSE'
      TYPE*,'ENTER N.'
      GO TO 200
110   TYPE*,'IF THE FREQUENCY OF THE PEAK DOES'
      TYPE*,'NOT CORRESPONDS TO ANY OF THE SPIN'
      TYPE*,'LINES THEN ENTER YOUR CALCULATED'
```

```
        TYPE*,'FREQUENCY AT THIS TIME.'
        GO TO 210
30      IC1(IFLAGY)=IC1(IFLAGY)+1
        TYPE*,'ENTER THE SPIN LINE NUMBER'
220     ACCEPT 20,(STRING(I),I=1,10)
        CALL CONVER(STRING,HELP,FR)
        IF(HELP)GO TO 120
        FREQ=X(1)/FR
        RETURN
120     TYPE*,'THIS QUESTION REFERS TO THE'
        TYPE*,'NUMBER OF THE SPIN LINE THAT'
        TYPE*,'CONTAINS THE PEAK IN QUESTION'
        TYPE*,'PLEASE ENTER THE NUMBER FOR '
        TYPE*,'THAT LINE.'
        GO TO 220
        END
>
```

```
      SUBROUTINE SPTRK1(X,MAX,N,FREQ,Y,Z,T1,IFLAGY)
      DIMENSION Y(1),Z(1),P(5)
      COMMON /STAT1/NSEG1,WIN1,IC1(2),IC2(2),IC3(2),IC4(2),
     1PC1,PC2,PC3,PC4
      DO 100 I=MAX,4,-4
      FREQ1=FREQ*I+X
      FREQ2=FREQ*I-X
      NCOUNT=0
      DO 90 J=1,N
      IF(Y(J))10,20,20
10    IF(Y(J).GT.(-FREQ2).OR.Y(J).LT.(-FREQ1))GO TO 90
      GO TO 30
20    IF(Y(J).GT.FREQ1.OR.Y(J).LT.FREQ2)GO TO 90
30    NCOUNT=NCOUNT+1
      P(NCOUNT)=Y(J)
90    CONTINUE
      NUM=I
      IF(NCOUNT.NE.0) GO TO 110
100   CONTINUE
110   IF(NCOUNT.EQ.1)GO TO 125
      IF(NCOUNT.EQ.0)GO TO 120
      IF(NCOUNT.NE.2)GO TO 115
      IF(ABS(P(1)+P(2)).LT.3.)GO TO 125
115   CALL MENU1(P,NCOUNT,NUM,T1)
      IC4(IFLAGY)=IC4(IFLAGY)+1
      GO TO 130
120   CALL MENU2(FREQ,T1)
      IC2(IFLAGY)=IC2(IFLAGY)+1
      RETURN
125   IC3(IFLAGY)=IC3(IFLAGY)+1
130   FREQ=ABS(P(1))/NUM
      RETURN
      END
>
```

Appendix A (cont)

```
      SUBROUTINE SPFIT(SPFR,SPFREQ,ICOUNT,IFL)
C********************************************************
C*                                                      *
C*    THIS ROUTINE MAKES USE OF A 3 POINT LEAST         *
C*                                                      *
C*    SQUARES APPROXIMATION TO PREDICT THE NEXT         *
C*                                                      *
C*    WINDOW CENTER VALUE.                              *
C*                                                      *
C********************************************************
      DIMENSION SPFR(120,2)
      SUM=SPFR(ICOUNT,IFL)+SPFR(ICOUNT-1,IFL)+SPFR(ICOUNT-2,IFL)
      SLOPE=SPFR(ICOUNT,IFL)+.5*(SPFR(ICOUNT-1,IFL)-SUM)
      B=(1./3.)*SUM-SLOPE
      SPFREQ=3.*SLOPE+B
      RETURN
      END
>
```

```
      SUBROUTINE REVDAT(SPFR,ICO,NLINES)
      DIMENSION SPFR(120,2),A(120)
      K=ICO+NLINES-1
      DO 10 I=ICO,ICO+NLINES-1
      A(I)=SPFR(K,2)
10    K=K-1
      DO 20 I=ICO,ICO+NLINES-1
20    SPFR(I,2)=A(I)
      RETURN
      END
>
```

```
SUBROUTINE COMPUT(NLINES,NFB,WINLEN)
COMMON /STAT1/NSEG1,WIN1,IC1(2),IC2(2),IC3(2),IC4(2),
1PC1,PC2,PC3,PC4
A=NLINES
NSEG1=NSEG1+1
WIN1=(WIN1+WINLEN)/2.
PC1=PC1+IC1(NFB)
PC2=(PC2+IC2(NFB)/A)/2.
PC3=(PC3+IC3(NFB)/A)/2.
PC4=(PC4+IC4(NFB)/A)/2.
RETURN
END
```

```
SUBROUTINE COMFIN(NPEAKS)
COMMON /STAT/NRUNS,NAVEPE,AVE4FS,N60HZ,SPFREK,IFILTR,NUMLIN,
1NSEG,WINAVE,PCNT1,PCNT2,PCNT3,PCNT4
COMMON /STAT1/NSEG1,WIN1,IC1(2),IC2(2),IC3(2),IC4(2),
1PC1,PC2,PC3,PC4
LOGICAL IFILTR
NRUNS=NRUNS+1
NAVEPE=(NAVEPE+NPEAKS)/2
AVE4FS=(AVE4FS+SPFREK)/2
IF(IFILTR)N60HZ=N60HZ+1
NSEG=NSEG+NSEG1
WINAVE=(WINAVE+WIN1)/2
PCNT1=PCNT1+PC1
PCNT2=(PCNT2+PC2)/2
PCNT3=(PCNT3+PC3)/2
PCNT4=(PCNT4+PC4)/2
RETURN
END
```

```
      SUBROUTINE MENU1(P,NCOUNT,NUM,T1)
      DIMENSION P(1)
      TYPE*,'MORE THAN ONE PEAK WAS FOUND AT',T1
      TYPE*,'SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN'
      TYPE*,'ARE FOR EITHER THE + OR-',NUM,'FS LINE'
      DO 10 J=1,NCOUNT
10    TYPE*,J,P(J)
      TYPE*,'I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,'
      TYPE*,'DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N'
      ACCEPT 15,ANSW
15    FORMAT(A1)
      IF(ANSW.NE.'Y')RETURN
      TYPE*,'IS ANY OF THE LISTED ONES RIGHT?Y,N'
      ACCEPT 15,ANSW
      IF(ANSW.EQ.'Y')GO TO 30
      TYPE*,'ENTER THE RIGHT FREQUENCY FOR EITHER THE +OR-',NUM,'FS LINE
     ,'
      TYPE*,'AT',T1,'SECONDS'
      ACCEPT*,P(1)
      RETURN
30    TYPE*,'ENTER NUMBER FOR THE RIGHT ONE'
      ACCEPT*,I
      P(1)=P(I)
      RETURN
      END
>
```

```
SUBROUTINE MENU2(FREQ,T1)
TYPE*,'I COULD NOT FIND ANY MULTIPLES OF THE SPIN AT'
TYPE*,T1,'SECONDS,FOR THE WINDOW GIVEN'
TYPE*,'PLEASE ENTER THE SPIN FREQUENCY AT THIS LOCATION'
ACCEPT*,FREQ
TYPE*,'THANK YOU'
RETURN
END
```

```
SUBROUTINE SUG1(NLINES,MAXMUL)
COMMON/STAT/NRUNS,NAVEPE,AVE4FS,N60HZ,SPFREK,IFILTR,NUMLIN,
1NSEG,WINAVE,PCNT1,PCNT2,PCNT3,PCNT4
COMMON/STAT1/NSEG1,WIN1,IC1(2),IC2(2),IC3(2),IC4(2),
1PC1,PC2,PC3,PC4
LOGICAL IFILTR
TYPE*,MAXMUL,'WAS THE MAXIMUM MULTIPLE TO'
TYPE*,'LOOK FOR IN THIS INTERVAL.'
TYPE*,'YOU CAN ASK THE TRACKER TO LOOK FOR'
TYPE*,'A SMALLER MULTIPLE IF THERE ARE'
TYPE*,'NOISY PEAKS CLOSER TO THE MAXIMUM'
TYPE*,'MULTIPLE,OR IF YOU SEE THAT A SMALLER'
TYPE*,'MULTIPLE LINE IS STRONGER AND THIS'
TYPE*,'IS THE ONE YOU WANT TO TRACK.'
TYPE*,'1'
TYPE*,'OUT OF',NLINES,'LINES TRACKED,YOU'
TYPE*,'WERE ASKED TO INPUT THE CORRECT FRE-'
TYPE*,'QUENCY',IC2(1),'TIMES IN THE FORWARD'
TYPE*,'PROCESS,AND',IC2(2),'TIMES IN THE'
TYPE*,'BACKWARDS PROCESS.IF THESE TWO NUMBERS'
TYPE*,'ARE TOO LARGE COMPARED TO THE NUMBER'
TYPE*,'OF LINES IN THE INTERVAL,THIS MEANS'
TYPE*,'THAT YOUR WINDOW IS TOO SMALL,OR THAT'
TYPE*,'THERE ARE LARGE NOISE PEAKS CLOSE TO'
TYPE*,'THE CORRECT ONES.IF THE WINDOW LOOKS'
TYPE*,'SMALL, TRY LOOSING IT UP A LITTLE'
TYPE*,'BIT AND RUN IT AGAIN.IF THE PROBLEM'
TYPE*,'IS NOISE THEN SEE IF YOU CAN DIVIDE'
TYPE*,'THIS INTERVAL INTO SMALLER ONES,AND'
TYPE*,'AVOID PROCESSING THE NOISY INTERVALS.'
TYPE*,'IF THE NOISE PEAKS SEEM TO BE FAR'
TYPE*,'AWAY FROM THE SPIN LINES,AND YOU HAVE'
TYPE*,'A LARGE WINDOW, RUN THIS INTERVAL AGAIN'
TYPE*,'WITH A TIGHTER WINDOW.'
```

```
TYPE*,'THE AVERAGE WINDOW SIZE FOR PREVIOUS'
TYPE*,'RUNS WAS',WINAVE,'HERTZ.'
TYPE*,'IF THE WHOLE INTERVAL IS CORRUPTED'
TYPE*,'BY NOISE,DO NOT PROCESS IT.'
RETURN
END
```

```
SUBROUTINE SUG2
COMMON/STAT/NRUNS,NAVEPE,AVE4FS,N60HZ,SPFREK,IFILTR,NUMLIN,
1NSEG,WINAVE,PCNT11,PCNT2,PCNT3,PCNT4
COMMON/STAT1/NSEG1,WIN1,IC1(2),IC2(2),IC3(2),IC4(2),
1PC1,PC2,PC3,PC4
LOGICAL IFILTR
TYPE*,'THE FOLLOWING SUGGESTIONS CAN PROBABLY'
TYPE*,'IMPROVE YOUR OUTPUT,IT IS NO GUARANTEE'
TYPE*,'BUT YOU CAN TRY THEM BEFORE DOING THE'
TYPE*,'TRACKING MANUALLY.'
TYPE*,'1'
TYPE*,'IF YOU HAVE ALREADY TRY TO ADJUST THE'
TYPE*,'WINDOW OR THE MAXIMUM MULTIPLE,OR THE '
TYPE*,'TIME INTERVALS IN THIS PROCESS,AND YOU'
TYPE*,'STILL DO NOT HAVE A SATISFACTORY RUN,'
TYPE*,'THEN THE FOLLOWING APPLY TO THE PEAKS1'
TYPE*,'PROGRAM,HERE ARE SOME STATISTICS FIRST.'
TYPE*,'IN THIS RUN,',NSEG1,'SEGMENTS WERE PROCESSED'
TYPE*,'WITH AN AVERAGE WINDOW SIZE OF',WIN1,'HERTZ'
TYPE*,'IF YOU HAVE BEEN ASKED FOR THE CORRECT'
TY?E*,'FREQUENCY MANY TIMES,AND ALREADY HAVE'
TYPE*,'ADJUSTED YOUR WINDOW, THEN THERE EXIST'
TYPE*,'THE POSSIBILITY THAT YOU HAVE NOT SAVED'
TYPE*,'ENOUGH PEAKS IN THE INPUT FILE TO ACCO-'
TYPE*,'MODATE THOSE THAT DEFINE THE SPIN LINES'
TYPE*,'RUN THE PEAKS1 PROGRAM AGAIN AND INCREASE'
TYPE*,'THE NUMBER OF PEAKS SAVED BY 2 OR 3.'
TYPE*,'CHECK IF THE +/- 60 HZ LINE IS IN THE'
TYPE*,'DATA AND SCRATCH IT,ALTHOUGH THIS IS NOT '
TYPE*,'A BIG PROBLEM,IF IT IS TOO STRONG IT WILL '
TYPE*,'PREVENT SOME OF THE PEAKS TO BE SAVED.'
TYPE*,'CHECK IF THE 4FS FREQUENCY IS CORRECT.'
TYPE*,'AND GOOD LUCK.'
RETURN
END
```

```
      SUBROUTINE PRINTS(NPEAKS)
      COMMON /STAT/NRUNS,NAVEPE,AVE4FS,N60HZ,SPFREK,IFILTR,NUMLIN,
     1NSEG,WINAVE,PCNT1,PCNT2,PCNT3,PCNT4
      COMMON/STAT1/NSEG1,WIN1,IC1(2),IC2(2),IC3(2),IC4(2),
     1PC1,PC2,PC3,PC4
      LOGICAL IFILTR
      TYPE*,'THE FOLLOWING ARE THE STATISTICS FOR'
      TYPE*,'THIS RUN,INCLUDING THE PARAMETERS FOR'
      TYPE*,'THE PEAKS1 PROCESS PREVIOUSLY RUN.'
      TYPE*,'THIS HAS BEEN RUN NUMBER',NRUNS
      TYPE*,'THE NUMBER OF PEAKS SAVED'
      TYPE*,'PER SPECTRUM WAS',NPEAKS,'PEAKS.'
      TYPE*,'THE LOWEST FREQUENCY FOR THE'
      TYPE*,'4FS LINE WAS',SPFREK,'HERTZ.'
      TYPE*,'THE NUMBER OF SPECTRAL LINES'
      TYPE*,'PROCESSED WAS',NUMLIN
      TYPE*,'THE NUMBER OF SEGMENTS PROCESSED'
      TYPE*,'WAS',NSEG1
      IF(IFILTR)GO TO 10
      TYPE*,'THE +/- 60 HZ LINE WAS NOT REMOVED'
      GO TO 20
10    TYPE*,'THE +/- 60 HZ LINE WAS REMOVED'
20    TYPE*,'FOR THE SEGMENTS PROCESSED'
      TYPE*,'THE PROGRAM FOUND THE FIRST'
      TYPE*,'FREQUENCY',PC1,'TIMES.'
      TYPE*,'THE PERCENTAGE OF TIMES THAT'
      TYPE*,'THE USER ENTERED THE RIGHT'
      TYPE*,'FREQUENCY WAS',PC2,'%'
      TYPE*,'THE PERCENTAGE OF TIMES THAT'
      TYPE*,'THE PROGRAM FOUND MORE THAN'
      TYPE*,'ONE FREQUENCY WAS',PC4,'%'
      TYPE*,'THE PERCENTAGE OF TIMES THAT'
      TYPE*,'THE PROGRAM FOUND THE RIGHT'
      TYPE*,'FREQUENCY WAS',PC3,'%'
      RETURN
      END
```

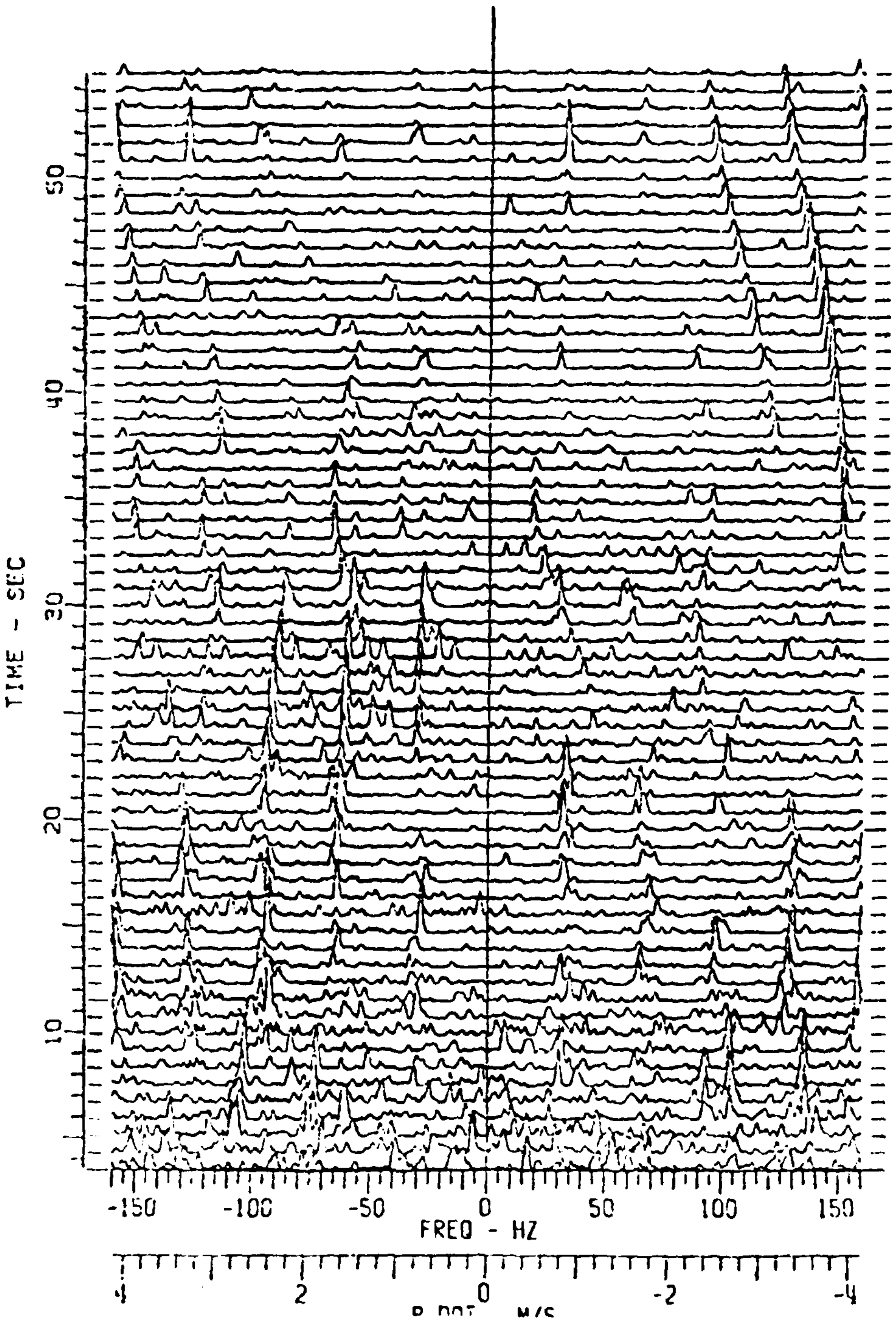


Figure B-1. Data set 1.

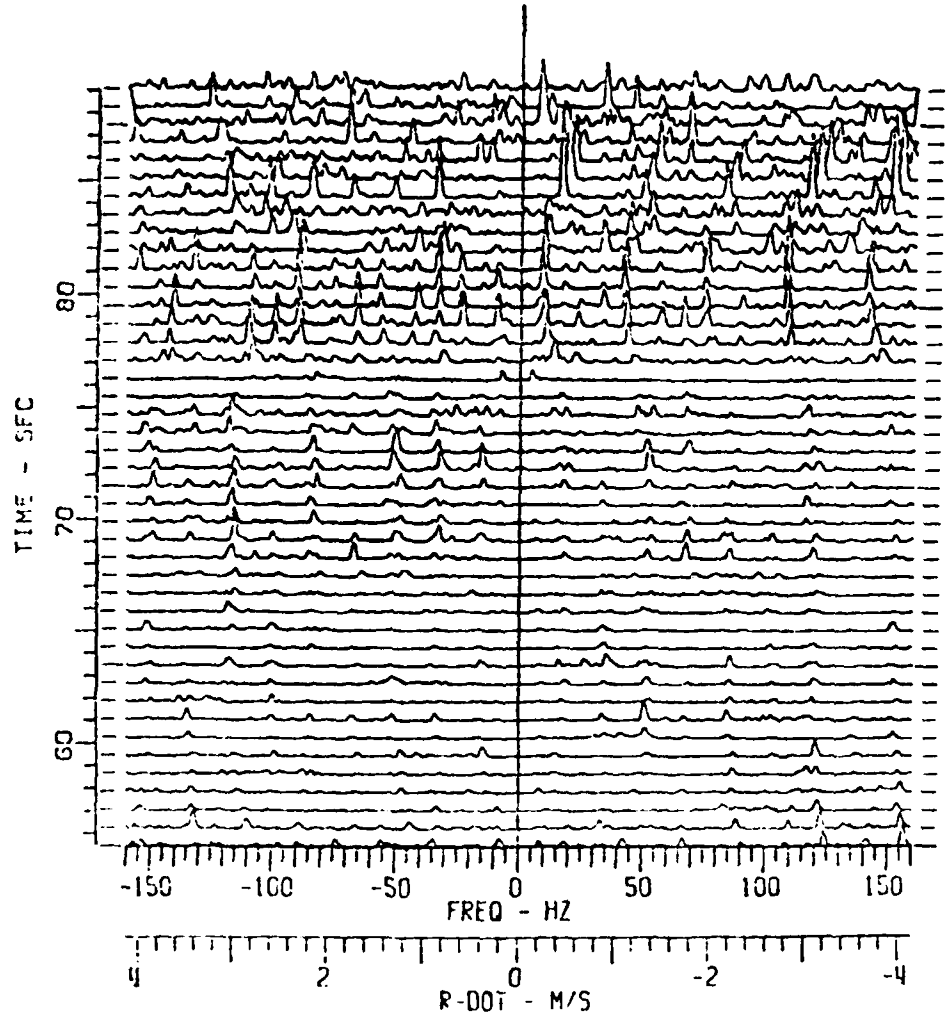


Figure B 1 (cont)

```
ENTER INPUT FILE NAME WITH DEVICE
CUM.COR;3
CUM.COR;3
ENTER OUTPUT FILE NAME WITH DEVICE
TEST1.DAT
TEST1.DAT
 IF YOU NEED HELP TO ANSWER ANY
 QUESTION ,ENTER HELP
ENTER STARTING TIME BIAS
0
 ENTER NUMBER OF PEAKS PER SPECTRUM YOU WANT TO SAVE
12
 ENTER MINIMUM FREQUENCY FOR THE 4FS LINE
20
 DO YOU WANT TO FILTER OUT THE+/-60HERTZ
 LINE?,ENTER Y OR N OR H (H IS FOR HELP)
N
TT1  --  STOP

>
```

```
 ENTER INPUT FILE NAME WITH DEVICE
TEST1.DAT
 IF YOU NEED HELP TO ANSWER
 ANY OF THE QUESTIONS,ENTER HELP
 ENTER TRACK WINDOW LENGTH
2
 ENTER MAXIMUM MULTIPLE TO LOOK FOR
16
 START TIME IS=   3.125709
 FINAL TIME IS=   89.08083
 ENTER TIME YOU WANT TO START AT
10.5
 ENTER TIME YOU WANT TO STOP AT
55
 FORWARD PROCESSING STARTS
 THE SPIN FREQUENCY FOR THE LARGEST PEAK
 AT   10.72317     SECONDS,IS   157.5851
 DOES THIS FREQUENCY CORRESPONDS TO ANY OF
 THE SPIN  LINES? Y OR N OR H (FOR HELP)
Y
 ENTER THE SPIN LINE NUMBER
20
 MORE THAN ONE PEAK WAS FOUND AT   10.72317
 SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
 ARE FOR EITHER THE + OR-     16 FS LINE
      1   126.3182
      2  -124.4422
      3   124.4422
 I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
 DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
N
```

```
 MORE THAN ONE PEAK WAS FOUND AT    11.52273
 SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
 ARE FOR EITHER THE + OR-     16 FS LINE
       1  -127.5689
       2   128.1942
       3   125.0675
 I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
 DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
N
 MORE THAN ONE PEAK WAS FOUND AT    13.92144
 SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
 ARE FOR EITHER THE + OR-     16 FS LINE
       1   128.8196
       2  -127.5689
       3   127.5689
       4   130.6956
 I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
 DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
Y
 IS ANY OF THE LISTED ONES RIGHT?Y,N
Y
 ENTER NUMBER FOR THE RIGHT ONE
2
 MORE THAN ONE PEAK WAS FOUND AT    17.11971
 SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
 ARE FOR EITHER THE + OR-     12 FS LINE
       1  -90.67397
       2  -92.54998
 I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
 DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
N
```

```
 I COULD NOT FIND ANY MULTIPLES OF THE SPIN AT
   23.51626      SECONDS,FOR THE WINDOW GIVEN
 PLEASE ENTER THE SPIN FREQUENCY AT THIS LOCATION
?.6
 THANK YOU
 I COULD NOT FIND ANY MULTIPLES OF THE SPIN AT
   26.71453      SECONDS,FOR THE WINDOW GIVEN
 PLEASE ENTER THE SPIN FREQUENCY AT THIS LOCATION
?.8
 THANK YOU
 MORE THAN ONE PEAK WAS FOUND AT    27.51410
 SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
 ARE FOR EITHER THE + OR-       4 FS LINE
       1  -31.89223
       2  -30.01620
 I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
 DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
?
 I COULD NOT FIND ANY MULTIPLES OF THE SPIN AT
   29.11323      SECONDS,FOR THE WINDOW GIVEN
 PLEASE ENTER THE SPIN FREQUENCY AT THIS LOCATION
?.5
 THANK YOU
 I COULD NOT FIND ANY MULTIPLES OF THE SPIN AT
   31.51194      SECONDS,FOR THE WINDOW GIVEN
 PLEASE ENTER THE SPIN FREQUENCY AT THIS LOCATION
?.8
```

```
THANK YOU
I COULD NOT FIND ANY MULTIPLES OF THE SPIN AT
  34.71021     SECONDS,FOR THE WINDOW GIVEN
PLEASE ENTER THE SPIN FREQUENCY AT THIS LOCATION
3.8
THANK YOU
I COULD NOT FIND ANY MULTIPLES OF THE SPIN AT
  38.70805     SECONDS,FOR THE WINDOW GIVEN
PLEASE ENTER THE SPIN FREQUENCY AT THIS LOCATION
3
THANK YOU
I COULD NOT FIND ANY MULTIPLES OF THE SPIN AT
  40.30718     SECONDS,FOR THE WINDOW GIVEN
PLEASE ENTER THE SPIN FREQUENCY AT THIS LOCATION
3
THANK YOU
I COULD NOT FIND ANY MULTIPLES OF THE SPIN AT
  41.90632     SECONDS,FOR THE WINDOW GIVEN
PLEASE ENTER THE SPIN FREQUENCY AT THIS LOCATION
3
THANK YOU
MORE THAN ONE PEAK WAS FOUND AT   42.70589
SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
ARE FOR EITHER THE + OR-     16 FS LINE
     1   142.5770
     2   144.4530
I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
Y
```

```
MORE THAN ONE PEAK WAS FOUND AT   45.90416
SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
ARE FOR EITHER THE + OR-     16 FS LINE
     1   137.5743
     2   135.6983
I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
Y
BACKWARDS PROCESSING STARTS
THE SPIN FREQUENCY FOR THE LARGEST PEAK
AT   54.69941      SECONDS,IS   156.9598
DOES THIS FREQUENCY CORRESPONDS TO ANY OF
THE SPIN  LINES? Y OR N OR H (FOR HELP)
Y
ENTER THE SPIN LINE NUMBER
20
MORE THAN ONE PEAK WAS FOUND AT   50.70156
SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
ARE FOR EITHER THE + OR-     16 FS LINE
     1  -127.5689
     2   128.1942
     3   130.0703
I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
Y
MORE THAN ONE PEAK WAS FOUND AT   45.90416
SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
ARE FOR EITHER THE + OR-     16 FS LINE
     1   137.5743
     2   135.6983
I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
Y
```

```
 MORE THAN ONE PEAK WAS FOUND AT   42.70589
 SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
 ARE FOR EITHER THE + OR-     16 FS LINE
       1   142.5770
       2  -141.9517
       3   144.4530
 I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
 DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
N
 MORE THAN ONE PEAK WAS FOUND AT   41.90632
 SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
 ARE FOR EITHER THE + OR-     16 FS LINE
       1   143.8277
       2  -143.8277
       3   145.7037
 I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
 DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
N
 MORE THAN ONE PEAK WAS FOUND AT   38.70805
 SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
 ARE FOR EITHER THE + OR-     16 FS LINE
       1   148.8304
       2   146.9544
 I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
 DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
N
 MORE THAN ONE PEAK WAS FOUND AT   36.30934
 SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
 ARE FOR EITHER THE + OR-     16 FS LINE
       1   149.4557
       2   150.7064
       3   152.5824
       4  -150.0811
 I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
```

```
 DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
Y
 IS ANY OF THE LISTED ONES RIGHT?Y,N
Y
 ENTER NUMBER FOR THE RIGHT ONE
2
 MORE THAN ONE PEAK WAS FOUND AT   34.71021
 SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
 ARE FOR EITHER THE + OR-     16 FS LINE
      1   151.9571
      2   153.2077
 I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
 DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
N
 I COULD NOT FIND ANY MULTIPLES OF THE SPIN AT
   29.91280      SECONDS,FOR THE WINDOW GIVEN
 PLEASE ENTER THE SPIN FREQUENCY AT THIS LOCATION
7.5
 THANK YOU
 I COULD NOT FIND ANY MULTIPLES OF THE SPIN AT
   27.51410      SECONDS,FOR THE WINDOW GIVEN
 PLEASE ENTER THE SPIN FREQUENCY AT THIS LOCATION
8
 THANK YOU
 I COULD NOT FIND ANY MULTIPLES OF THE SPIN AT
   25.91496      SECONDS,FOR THE WINDOW GIVEN
 PLEASE ENTER THE SPIN FREQUENCY AT THIS LOCATION
8
```

```
 THANK YOU
 I COULD NOT FIND ANY MULTIPLES OF THE SPIN AT
   24.31582      SECONDS,FOR THE WINDOW GIVEN
 PLEASE ENTER THE SPIN FREQUENCY AT THIS LOCATION
8
 THANK YOU
 MORE THAN ONE PEAK WAS FOUND AT   17.11971
 SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
 ARE FOR EITHER THE + OR-      4 FS LINE
      1   31.89223
      2   33.76823
 I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
 DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
N
 I COULD NOT FIND ANY MULTIPLES OF THE SPIN AT
   13.12187      SECONDS,FOR THE WINDOW GIVEN
 PLEASE ENTER THE SPIN FREQUENCY AT THIS LOCATION
8
 THANK YOU
 I COULD NOT FIND ANY MULTIPLES OF THE SPIN AT
   10.72317      SECONDS,FOR THE WINDOW GIVEN
 PLEASE ENTER THE SPIN FREQUENCY AT THIS LOCATION
8
```

Appendix B (cont)

THANK YOU

TIME	FORWARD PROCESS	BACKWARD PROCESS
10.72317	7.89489	8.00000
11.52273	7.97306	8.75473
12.32230	8.09031	8.09031
13.12187	8.02517	8.00000
13.92144	7.97306	7.76461
14.72101	7.93397	7.76461
15.52057	7.77764	7.77764
16.32014	7.71250	7.97306
17.11971	7.55616	7.97306
17.91928	7.55616	8.20756
18.71885	7.66039	8.23361
19.51842	7.73855	8.05122
20.31798	7.89489	8.01214
21.11755	8.05122	7.86883
21.91712	8.12939	7.76461
22.71669	8.20756	7.76461
23.51626	7.60000	7.81672
24.31582	7.60828	8.00000
25.11539	7.13927	7.73855
25.91496	7.03505	8.00000
26.71453	7.80000	7.50405
27.51410	7.97306	8.00000
28.31366	8.59839	5.51079
29.11323	7.50000	6.82660
29.91280	7.42589	7.50000
30.71237	6.64421	9.26282
31.51194	7.80000	9.34098
32.31150	7.54314	9.38007
33.11107	8.12939	9.45823
33.91064	8.20756	9.41915
34.71021	8.80000	9.49732
35.50977	9.22373	9.45823

36.30934	9.69273	9.41915
37.10891	10.10963	9.38007
37.90848	10.63074	9.34098
38.70805	8.00000	9.30190
39.50761	7.42589	9.22373
40.30718	9.00000	9.14557
41.10675	9.10648	9.10648
41.90632	9.00000	8.98923
42.70589	8.91106	8.91106
43.50546	8.83290	8.83290
44.30502	8.75473	8.75473
45.10459	8.67656	8.67656
45.90416	8.59839	8.59839
46.70372	8.48114	8.48114
47.50329	8.36389	8.36389
48.30286	8.28572	8.28572
49.10243	8.20756	8.20756
49.90200	8.09031	8.09031
50.70156	7.97306	7.97306
51.50113	7.97306	7.97306
52.30070	7.89489	7.89489
53.10027	7.85580	7.85580
53.89984	7.81672	7.81672
54.69941	7.77764	7.77764

```
 DO YOU AGREE WITH THE DATA?,
 EITHER FORWARD OR BACKWARDS
 ENTER Y OR N.
Y
 DO YOU WANT TO SAVE THE FORWARD
 OR THE BACKWARD DATA? ENTER
 1 FOR THE FORWARD DATA
 2 FOR THE BACKWARD DATA
2
```

```
 DO YOU WANT TO PROCESS MORE
 SEGMENTS OF DATA? ENTER Y OR N
Y
 DO YOU AGREE WITH THIS RUN?
 ENTER Y OR N
Y
 DO YOU WANT TO SEE THE STATISTICS
 OF THIS RUN? ENTER Y OR N.
Y
TT1  --  STOP

>
```

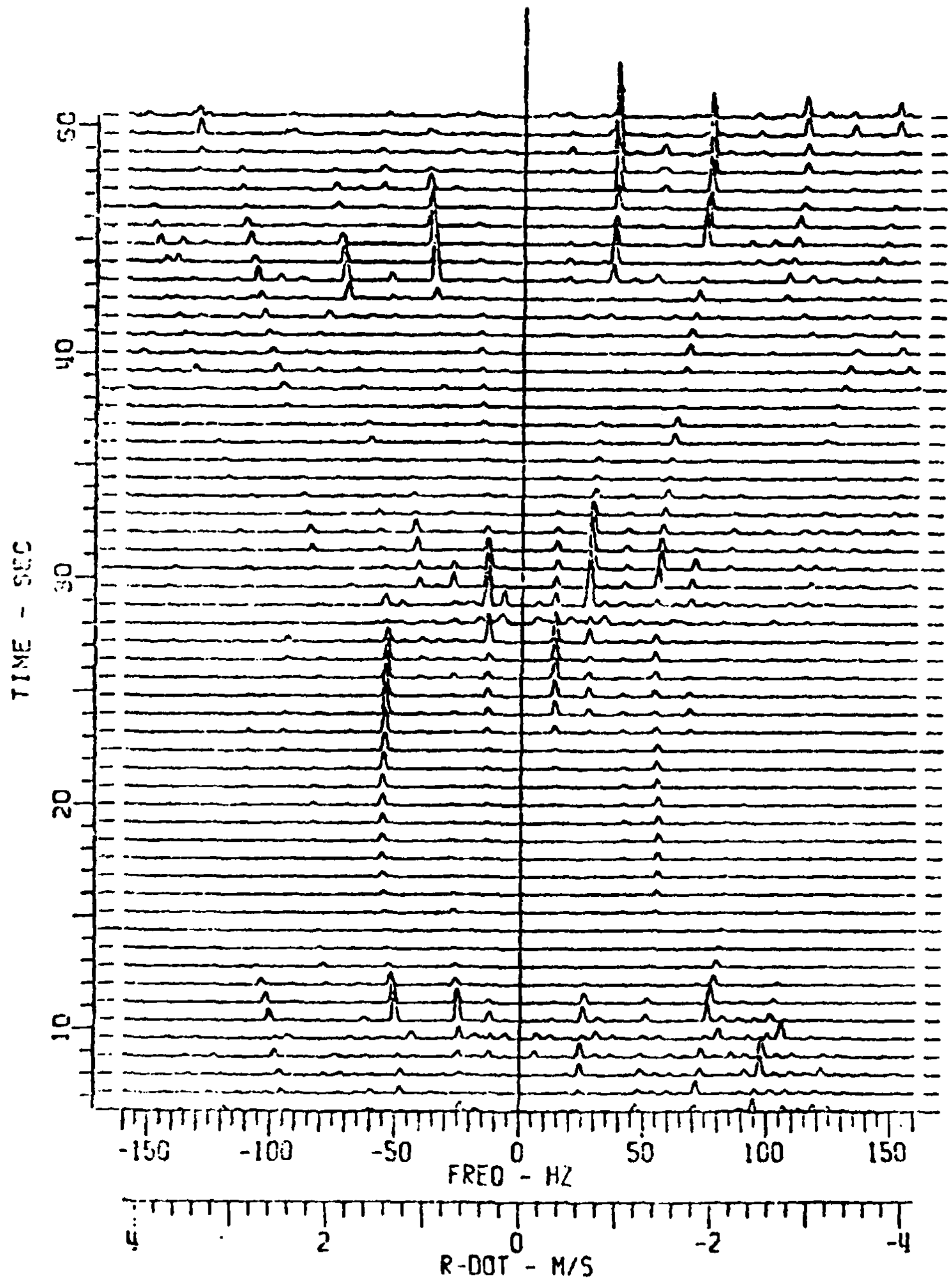


Figure B-2. Data set 2.

```
ENTER INPUT FILE NAME WITH DEVICE
CUM.COR;4
CUM COR;4
ENTER OUTPUT FILE NAME WITH DEVICE
TEST2.DAT
TEST2.DAT
 IF YOU NEED HELP TO ANSWER ANY
 QUESTION ,ENTER HELP
ENTER STARTING TIME BIAS
2
 ENTER NUMBER OF PEAKS PER SPECTRUM YOU WANT TO SAVE
9
 ENTER MINIMUM FREQUENCY FOR THE 4FS LINE
20
 DO YOU WANT TO FILTER OUT THE+/-60HERTZ
 LINE?,ENTER Y OR N OR H (H IS FOR HELP)
N

TT2  --  STOP

>
```

```
 ENTER INPUT FILE NAME WITH DEVICE
TEST2.DAT
 IF YOU NEED HELP TO ANSWER
 ANY OF THE QUESTIONS,ENTER HELP
 ENTER TRACK WINDOW LENGTH
2
 ENTER MAXIMUM MULTIPLE TO LOOK FOR
16
 START TIME IS=   6.042116
 FINAL TIME IS=   50.41970
 ENTER TIME YOU WANT TO START AT
16
 ENTER TIME YOU WANT TO STOP AT
50
 FORWARD PROCESSING STARTS
 THE SPIN FREQUENCY FOR THE LARGEST PEAK
 AT   16.03828      SECONDS,IS   55.02972
 DOES THIS FREQUENCY CORRESPONDS TO ANY OF
 THE SPIN  LINES? Y OR N OR H (FOR HELP)
Y
 ENTER THE SPIN LINE NUMBER
8
 BACKWARDS PROCESSING STARTS
 THE SPIN FREQUENCY FOR THE LARGEST PEAK
 AT   49.62013      SECONDS,IS   38.14560
 DOES THIS FREQUENCY CORRESPONDS TO ANY OF
 THE SPIN  LINES? Y OR N OR H (FOR HELP)
Y
 ENTER THE SPIN LINE NUMBER
4
```

Appendix B (cont)

TIME	FORWARD PROCESS	BACKWARD PROCESS
16.03928	6.87872	6.87872
16.83785	6.91780	6.91780
17.63741	6.93083	6.93083
18.43698	6.93083	6.93083
19.23655	6.93083	6.93083
20.03612	6.91780	6.91780
20.83569	6.87872	6.87872
21.63525	6.87872	6.87872
22.43482	6.83963	6.83963
23.23439	6.80055	6.80055
24.03396	6.77449	6.77449
24.83353	6.76146	6.76146
25.63309	6.72238	6.72238
26.43266	6.72238	6.72238
27.23223	6.72238	6.72238
28.03180	6.80055	6.80055
28.83137	6.80055	6.80055
29.63093	6.80055	6.80055
30.43050	6.95688	6.98294
31.23007	6.98294	6.98294
32.02964	7.07413	7.07413
32.82920	7.19138	7.19138
33.62877	7.24350	7.24350
34.42834	7.34772	7.34772
35.22791	7.50405	7.50405
36.02748	7.62130	7.62130
36.82705	7.77764	7.77764
37.62661	7.93397	7.93397
38.42618	8.09031	8.09031
39.22575	8.20756	8.20756
40.02532	8.36389	8.36389
40.82489	8.52023	8.52023
41.62445	8.65051	8.65051

```
42.42402          8.79381          8.79381
43.22359          8.91106          8.91106
44.02316          9.02831          9.02831
44.82273          9.14556          9.14556
45.62230          9.22373          9.22373
46.42186          9.38007          9.38007
47.22143          9.43218          9.43218
48.02100          9.48429          9.48429
48.82057          9.48429          9.48429
49.62013          9.49732          9.49732
 DO YOU AGREE WITH THE DATA?,
 EITHER FORWARD OR BACKWARDS
 ENTER Y OR N.
Y
 DO YOU WANT TO SAVE THE FORWARD
 OR THE BACKWARD DATA? ENTER
 1 FOR THE FORWARD DATA
 2 FOR THE BACKWARD DATA
1
 DO YOU WANT TO PROCESS MORE
 SEGMENTS OF DATA? ENTER Y OR N
N
 DO YOU AGREE WITH THIS RUN?
 ENTER Y OR N
Y
 DO YOU WANT TO SEE THE STATISTICS
 OF THIS RUN? ENTER Y OR N.
N

TT2  --  STOP

>
```

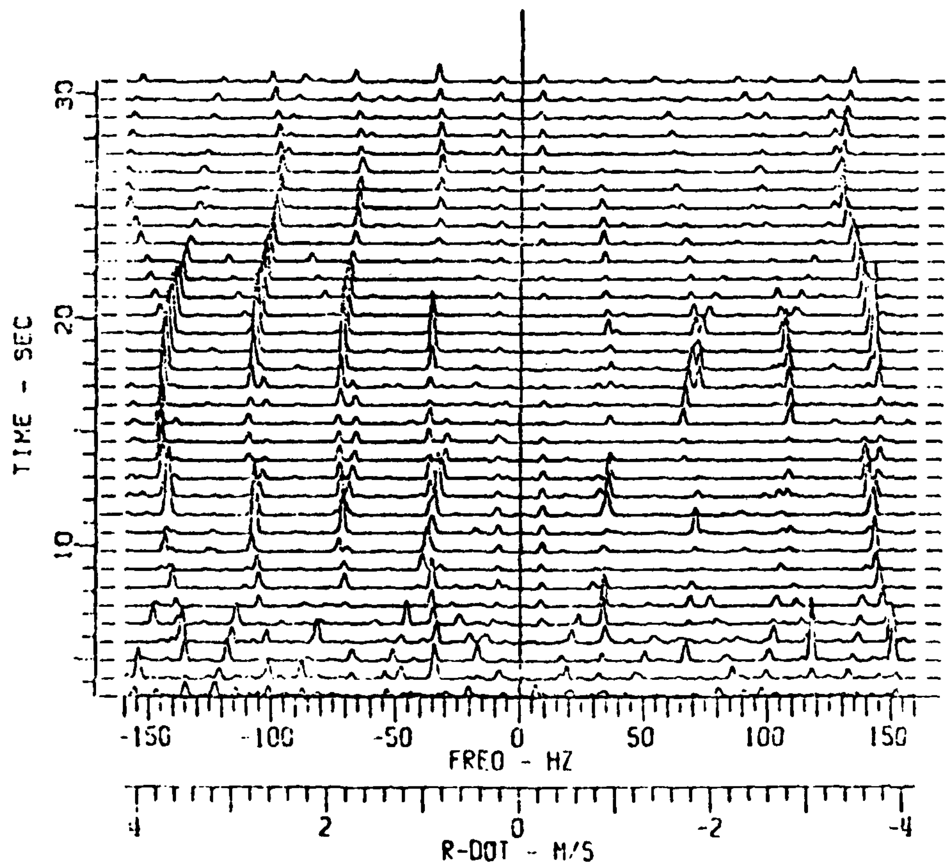


Figure B-3. Data set 3.

Appendix B (cont)

```
ENTER INPUT FILE NAME WITH DEVICE
CUM.COR:5
CUM.COR;5
ENTER OUTPUT FILE NAME WITH DEVICE
TEST3.DAT
TEST3.DAT
 IF YOU NEED HELP TO ANSWER ANY
 QUESTION ,ENTER HELP
ENTER STARTING TIME BIAS
0
 ENTER NUMBER OF PEAKS PER SPECTRUM YOU WANT TO SAVE
 2
 ENTER MINIMUM FREQUENCY FOR THE 4FS LINE
25
 DO YOU WANT TO FILTER OUT THE+/-60HERTZ
 LINE?,ENTER Y OR N OR H (H IS FOR HELP)
N

TT2  --  STOP

>
```

```
ENTER INPUT FILE NAME WITH DEVICE
TEST3.DAT
 IF YOU NEED HELP TO ANSWER
 ANY OF THE QUESTIONS,ENTER HELP
 ENTER TRACK WINDOW LENGTH
/
 ENTER MAXIMUM MULTIPLE TO LOOK FOR
16
 START TIME IS=    2.958024
 FINAL TIME IS=    30.54456
 ENTER TIME YOU WANT TO START AT
5
 ENTER TIME YOU WANT TO STOP AT
30
 FORWARD PROCESSING STARTS
 THE SPIN FREQUENCY FOR THE LARGEST PEAK
 AT    5.758054      SECONDS,IS    149.4557
 DOES THIS FREQUENCY CORRESPONDS TO ANY OF
 THE SPIN  LINES? Y OR N OR H (FOR HELP)
Y
 ENTER THE SPIN LINE NUMBER
16
 MORE THAN ONE PEAK WAS FOUND AT    9.755895
 SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
 ARE FOR EITHER THE + OR-      16 FS LINE
       1   143.2023
       2  -143.8277
       3  -141.9517
 I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
 DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
N
```

```
MORE THAN ONE PEAK WAS FOUND AT    10.55546
SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
ARE FOR EITHER THE + OR-      16 FS LINE
      1  -142.5770
      2  -141.3263
      3   141.3263
I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
Y
 IS ANY OF THE LISTED ONES RIGHT?Y,N
Y
 ENTER NUMBER FOR THE RIGHT ONE
2
 MORE THAN ONE PEAK WAS FOUND AT    25.74725
 SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
 ARE FOR EITHER THE + OR-      16 FS LINE
      1   128.8196
      2   126.9435
      3  -126.9436
 I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
 DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
Y
 IS ANY OF THE LISTED ONES RIGHT?Y,N
Y
 ENTER NUMBER FOR THE RIGHT ONE
2
 MORE THAN ONE PEAK WAS FOUND AT    27.34639
 SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
 ARE FOR EITHER THE + OR-      16 FS LINE
      1   129.4449
      2   126.3182
      3  -126.3182
 I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
 DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
```

```
Y
 IS ANY OF THE LISTED ONES RIGHT?Y,N
Y
 ENTER NUMBER FOR THE RIGHT ONE
2
 BACKWARDS PROCESSING STARTS
 THE SPIN FREQUENCY FOR THE LARGEST PEAK
 AT   29.74509     SECONDS,IS   131.9463
 DOES THIS FREQUENCY CORRESPONDS TO ANY OF
 THE SPIN  LINES? Y OR N OR H (FOR HELP)
Y
 ENTER THE SPIN LINE NUMBER
16
 MORE THAN ONE PEAK WAS FOUND AT   26.54682
 SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
 ARE FOR EITHER THE + OR-      16 FS LINE
       1   128.8196
       2   126.9435
       3  -128.8196
 I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
 DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N

 MORE THAN ONE PEAK WAS FOUND AT   25.74725
 SECONDS.THE PEAKS FOUND IN THE WINDOW GIVEN
 ARE FOR EITHER THE + OR-      16 FS LINE
       1   128.8196
       2   126.9435
       3  -125.9436
 I WILL CHOOSE THE FIRST ONE AS CORRECT,OTHERWISE,
 DO YOU WANT TO TELL ME WHICH IS THE CORRECT ONE?Y,N
Y
```

```
IS ANY OF THE LISTED ONES RIGHT?Y,N
Y
ENTER NUMBER FOR THE RIGHT ONE
2
I COULD NOT FIND ANY MULTIPLES OF THE SPIN AT
  19.35071      SECONDS,FOR THE WINDOW GIVEN
PLEASE ENTER THE SPIN FREQUENCY AT THIS LOCATION
8.75
THANK YOU
I COULD NOT FIND ANY MULTIPLES OF THE SPIN AT
  17.75158      SECONDS,FOR THE WINDOW GIVEN
PLEASE ENTER THE SPIN FREQUENCY AT THIS LOCATION
8.7
THANK YOU
```

TIME	FORWARD PROCESS	BACKWARD PROCESS
5.75805	9.34098	9.34098
6.55762	9.30190	9.30190
7.35719	9.14557	9.14557
8.15676	9.06740	9.06740
8.95633	8.98923	8.98923
9.75589	8.95015	8.98923
10.55546	8.83290	8.91106
11.35503	8.87198	8.87198
12.15460	8.75473	8.59839
12.95417	8.71564	8.44206
13.75373	8.67656	8.28572
14.55330	8.63748	8.28572
15.35287	8.67656	8.28572
16.15244	8.54628	8.54628
16.95201	8.65051	8.65051
17.75158	8.59839	8.70000
18.55114	8.67656	8.91106
19.35071	8.80684	8.75000
20.15028	8.67656	6.91780

Appendix B (cont)

```
20.94985              8.63748              7.07413
21.74941              8.52023              7.19138
22.54898              8.44206              7.34772
23.34855              8.32481              7.54314
24.14812              8.20756              7.73855
24.94769              8.09031              7.89489
25.74725              7.93397              7.93397
26.54682              8.05122              8.05122
27.34639              7.89489              8.09031
28.14596              7.85580              8.12939
28.94553              7.77764              8.16847
29.74509              7.66039              8.24664
DO YOU AGREE WITH THE DATA?,
EITHER FORWARD OR BACKWARDS
ENTER Y OR N
Y
DO YOU WANT TO SAVE THE FORWARD
OR THE BACKWARD DATA? ENTER
1 FOR THE FORWARD DATA
2 FOR THE BACKWARD DATA
1
DO YOU WANT TO PROCESS MORE
SEGMENTS OF DATA? ENTER Y OR N
N
DO YOU AGREE WITH THIS RUN?
ENTER Y OR N
Y
DO YOU WANT TO SEE THE STATISTICS
OF THIS RUN? ENTER Y OR N.
N
TT2  --  STOP

>
```

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